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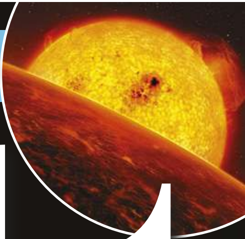
WEATHER REPORT: THE CLIMATES OF ALIEN WORLDS



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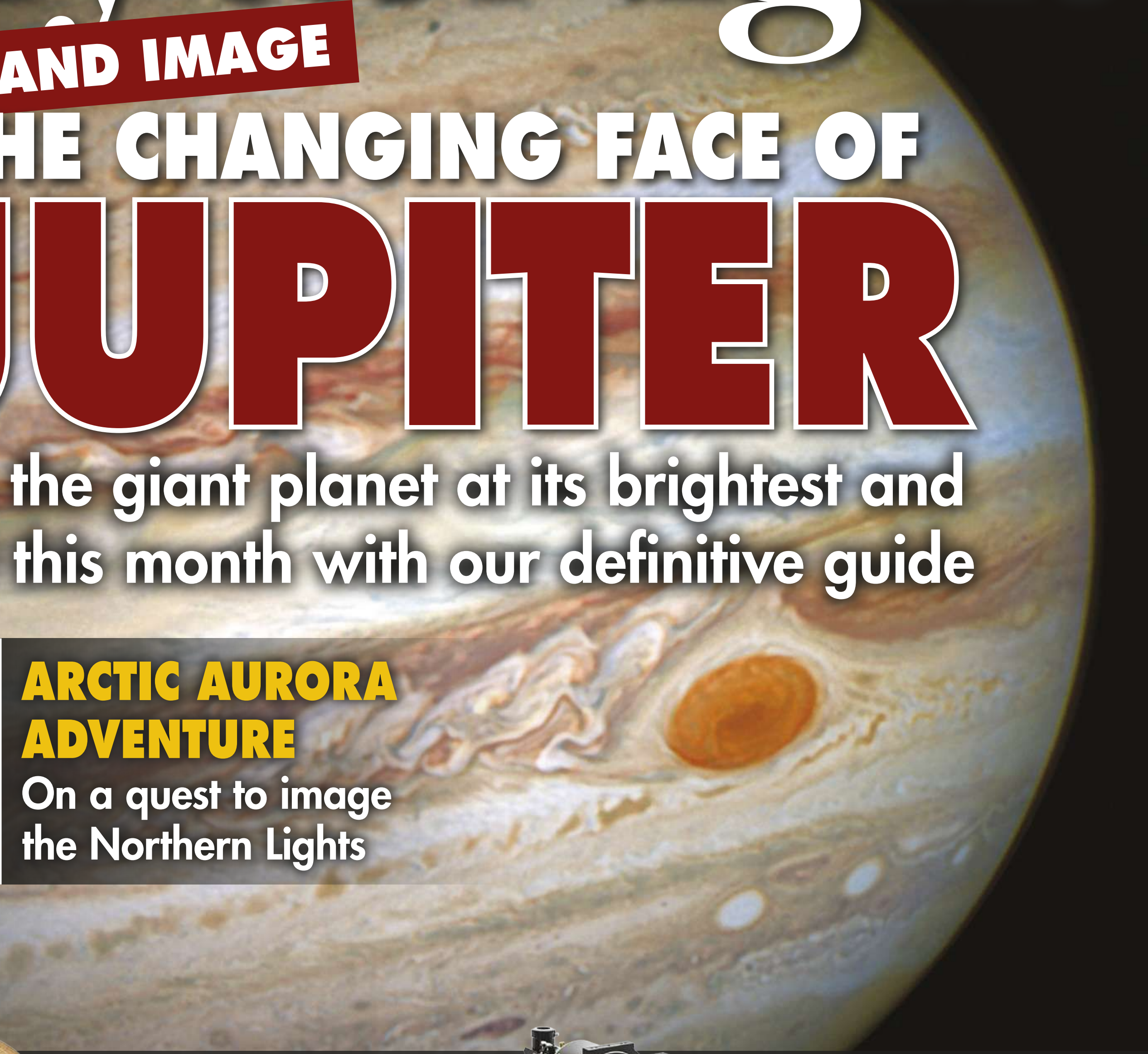

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See the giant planet at its brightest and best this month with our definitive guide

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On a quest to image the Northern Lights

THE FATE OF FARTHINGS

The inside story of Patrick Moore's lifetime collection

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REVIEWED IN
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This month's contributors include...

MAGGIE ADERIN-POCOCK
SKY AT NIGHT PRESENTER

Maggie sums up what we know (and don't know) about the Solar System's new planet. *Page 21*

DAMIAN PEACH
ASTRO IMAGER

Planetary imager Damian explains what you need to do to capture the magnificence of Jupiter with a camera. *Page 36*

JOHN ROGERS
BAA SECTION DIRECTOR

BAA Jupiter Section director John provides an invaluable update on the gas giant's key features ahead of opposition. *Page 34*

PAUL SUTHERLAND
ASTRONOMY JOURNALIST

What kinds of stars can form rocky planets like ours? Paul seeks out the latest research in our monthly *WIRK* column. *Page 106*

Welcome

As it reaches opposition, the brilliant beacon of Jupiter beckons

Jupiter has been the early risers' bright companion for several months now, but as it comes to opposition this month the giant planet reaches its brightest and best, and is visible all night. It's a great time to study the gas giant, and on page 33 you'll find guides from experts to help you do so: BAA Jupiter Section director John Rogers updates us on recent changes in its turbulent atmosphere, Paul Abel tells us how to observe and sketch the planet visually, and Damian Peach offers tips on how to create those sharp images of the planet for which he has become renowned.

Elizabeth Pearson reports on observations of planets further afield on page 39, where she describes the remarkable progress being made in determining the compositions of exoplanet atmospheres, and discovers that scientists have been able to discern traces of weather on worlds lightyears distant.

There are, however, rare instances when can we can study physical pieces of other worlds and on page 70 Will Gater looks at the samples returned from the Solar System and the science that is being done with them.

Enjoy the issue.

Chris Bramley Editor

PS Next issue goes on sale 17 March

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Sky at Night LOTS OF WAYS TO ENJOY THE NIGHT SKY...

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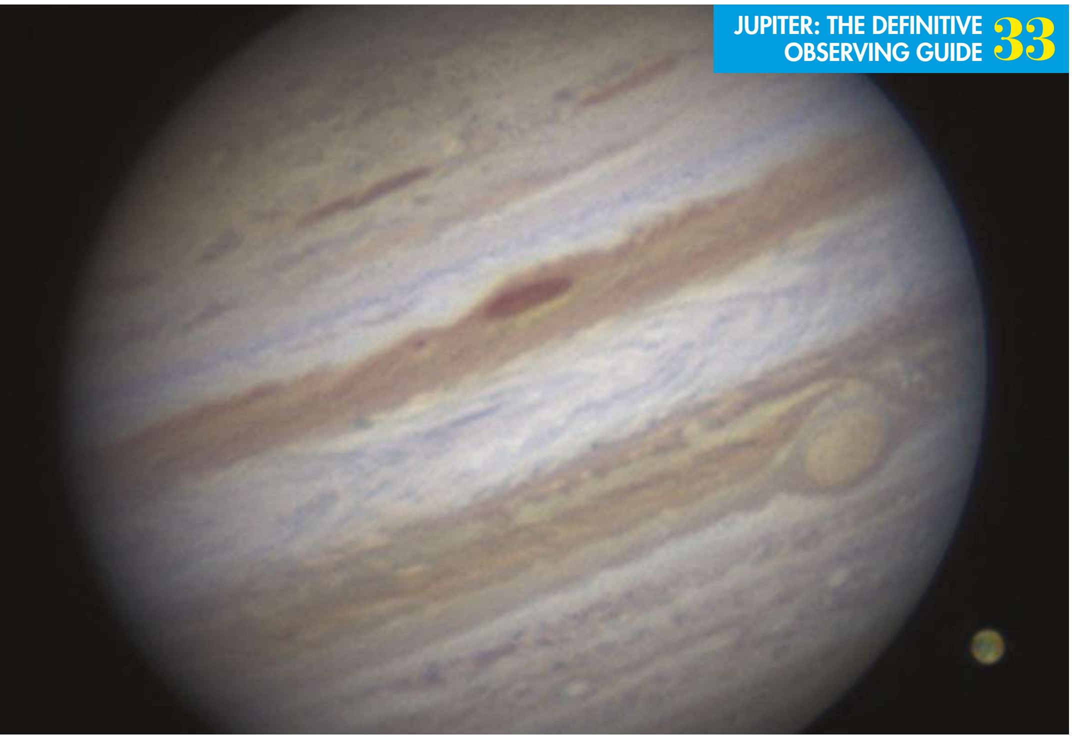
NEW TO ASTRONOMY?
See *The Guide* on page 78 and our online glossary at www.skyatnightmagazine.com/dictionary


JUPITER: THE DEFINITIVE OBSERVING GUIDE 33

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Ⓒ = on the cover

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LIFE IN THE UNIVERSE

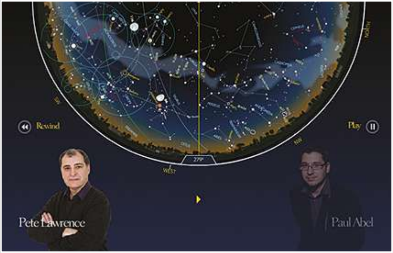
Are we alone in the vastness of the Universe? Could intelligent civilisations like our own be orbiting some distant star? In this classic *Sky at Night* episode from 1974, Patrick Moore interviews Dr Carl Sagan about the likelihood and consequences of discovering alien life, what it might look like and how it would ultimately change life on Earth.

EVERY MONTH

VIRTUAL PLANETARIUM

With Paul Abel and Pete Lawrence

Take a tour of March's night-sky highlights with Paul and Pete.



HIGHLIGHTS

INTERVIEW: JUNO

This month we talk to Juno principal investigator Scott Bolton about NASA's mission to study Jupiter. He discusses the spacecraft's journey so far, how it operates, what we have left to learn, and how data sent back to Earth will help us to uncover Jupiter's secrets.

VIDEO: SEARCHING FOR EXOPLANETS

The public is being invited to follow the hunt for planets outside our Solar System. Find out how in this new video from ESO.

NASA'S GUIDE TO THE JUNO MISSION

PDF guides released by NASA reveal the facts behind the Juno mission and how the probe will collect information.

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SUBSCRIPTION RATES
Annual subscription rates (inc P&P): UK cheque/credit card £59.88; Europe & Eire Airmail £69; rest of world airmail £79. To order, call 0844 844 0260

Audit Bureau of Circulations
24,576 (combined; Jan-Dec 2015)

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ISSN 1745-9869

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Briton in space

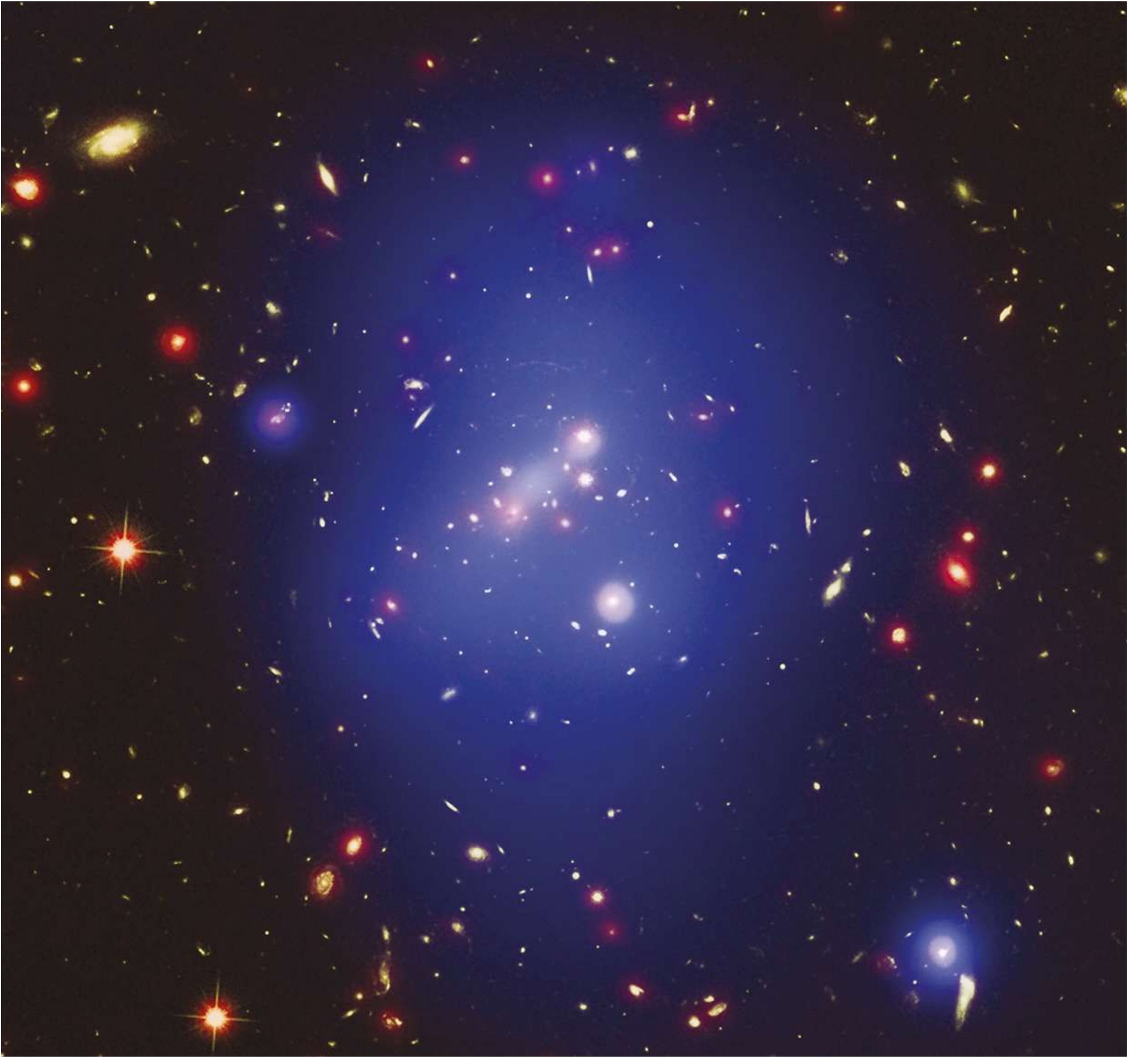
Tim Peake shows steady hands and nerves of steel as he works tethered to the International Space Station, becoming the first ESA-sponsored British astronaut to spacewalk

INTERNATIONAL SPACE STATION, 15 JANUARY 2016

Working with small components in darkness and in zero gravity, all while wearing a spacesuit: spacewalks are gruelling, but for astronauts like Tim Peake it's all in a day's work. In January, one month after blasting off to become the first official UK astronaut in space, Peake stepped outside the ISS with his NASA colleague Tim Kopra to become the first Briton to spacewalk since Michael Foale.

Their mission was to replace a 'sequential shunt unit' and restore the space station's solar panels to full capacity. The pair had to work while the ISS was hidden from the Sun to ensure the panels were not generating any power. Preparation involved breathing in pure oxygen for two hours to remove nitrogen from their bodies and prevent the onset of the bends. Getting in and out of the spacesuits took a few hours itself, even with the added benefit of having NASA veteran Scott Kelly on hand to assist.

Peake's Principia mission is due to last until May 2016. The Chichester-born astronaut will be spending his time conducting scientific research on the ISS, as well as outreach activites to inspire the next generation of space travellers back on Earth.

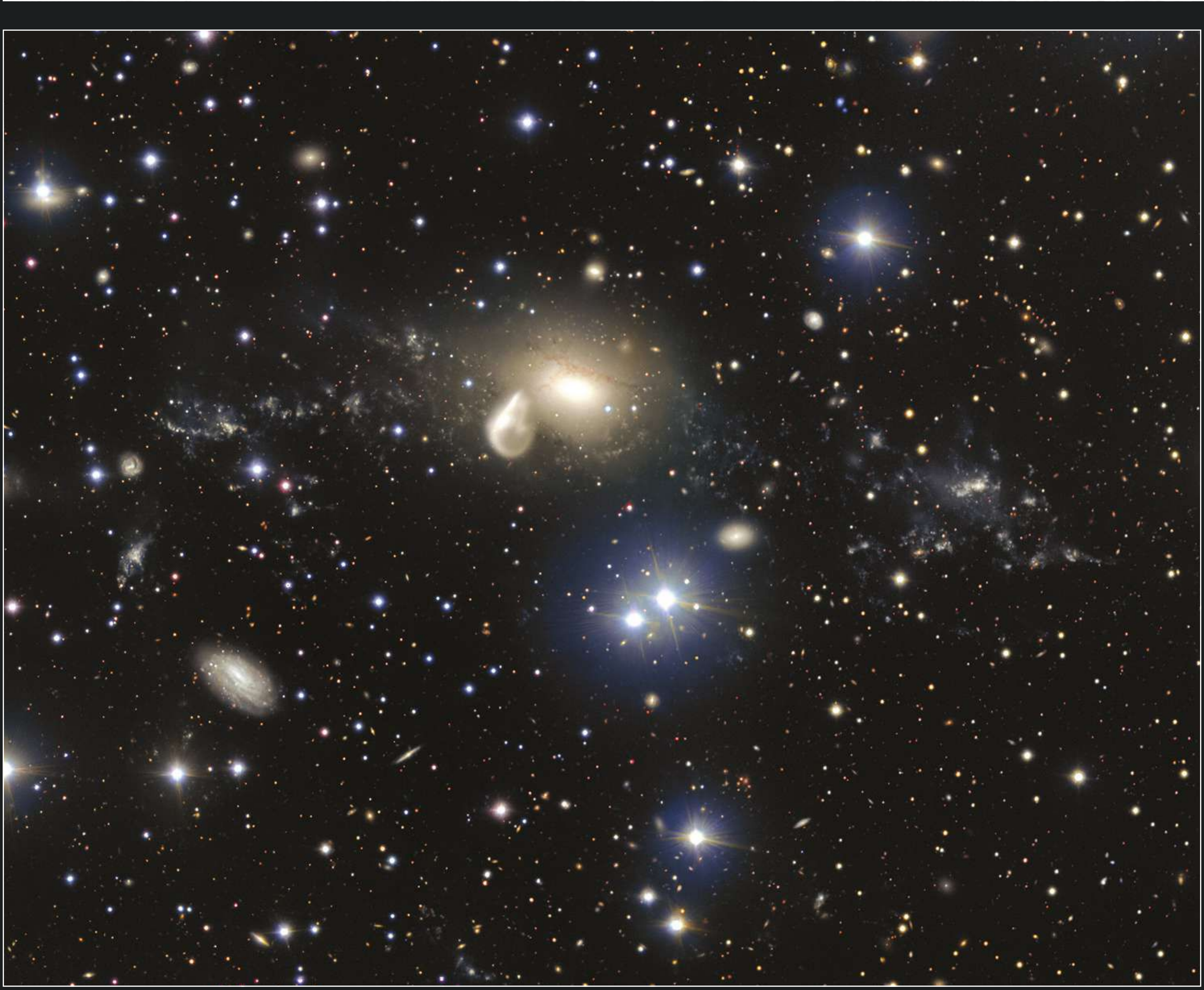


◀ The core of a cluster

CHANDRA X-RAY OBSERVATORY, HUBBLE SPACE TELESCOPE, SPITZER SPACE TELESCOPE, 7 JANUARY 2016

Galaxy clusters are the largest objects in the Universe to be bound together by gravity. IDCS J1426 weighs the same as 500 trillion of our Suns and was one of the earliest massive structures to form in the Universe. It is located some 10 billion lightyears from Earth, meaning astronomers are observing the galaxy cluster as it existed when the Universe was only about 3.8 billion years old. X-ray observations have revealed a core of gas within the galaxy cluster, as seen in blue at the centre of the image.

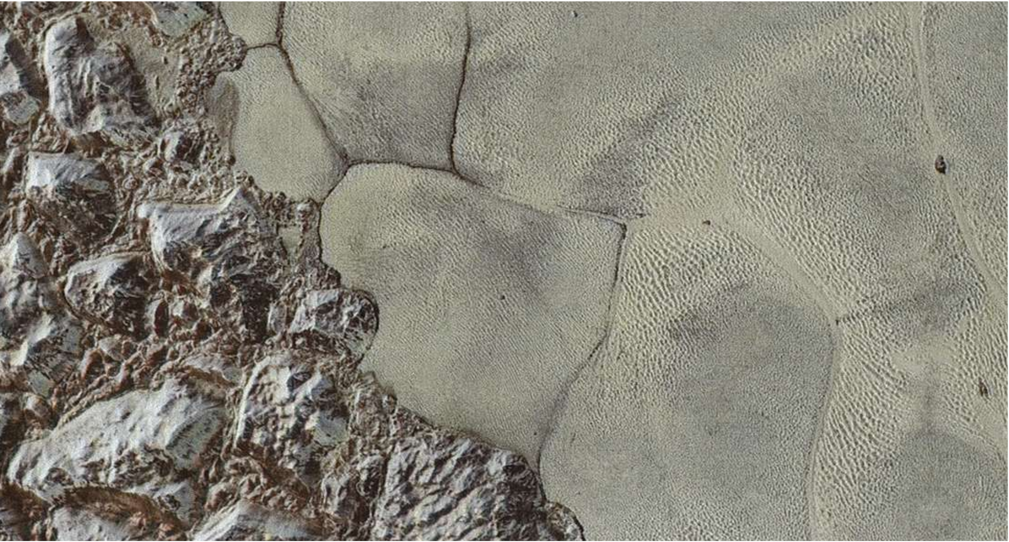
ESA/NASA, X-RAY: NASA/CXC/UNIVERSITY OF MISSOURI-KANSAS CITY/M.BRODWIN ET AL; OPTICAL: NASA/STSCI; INFRARED: JPL/CALTECH



▲ The scene after the storm

VERY LARGE TELESCOPE, 9 DECEMBER 2015

What you see here is the aftermath of a 360 million-year-old collision, when the golden oval at the centre of the image – elliptical galaxy NGC 5291 – collided with and disturbed another of its galactic brethren. The event would have spewed vast streams of gas into space, which have since collapsed into pockets of star-forming regions and dwarf galaxies, seen scattered around NGC 5291 in white and pale blue. The most massive and luminous of these, visible to the right of the galaxy, has its own designation – NGC 5291N. Astronomers are still unsure as to exactly how dwarf galaxies form, as they are thought to be common in the early Universe and are usually too distant to be observed effectively.



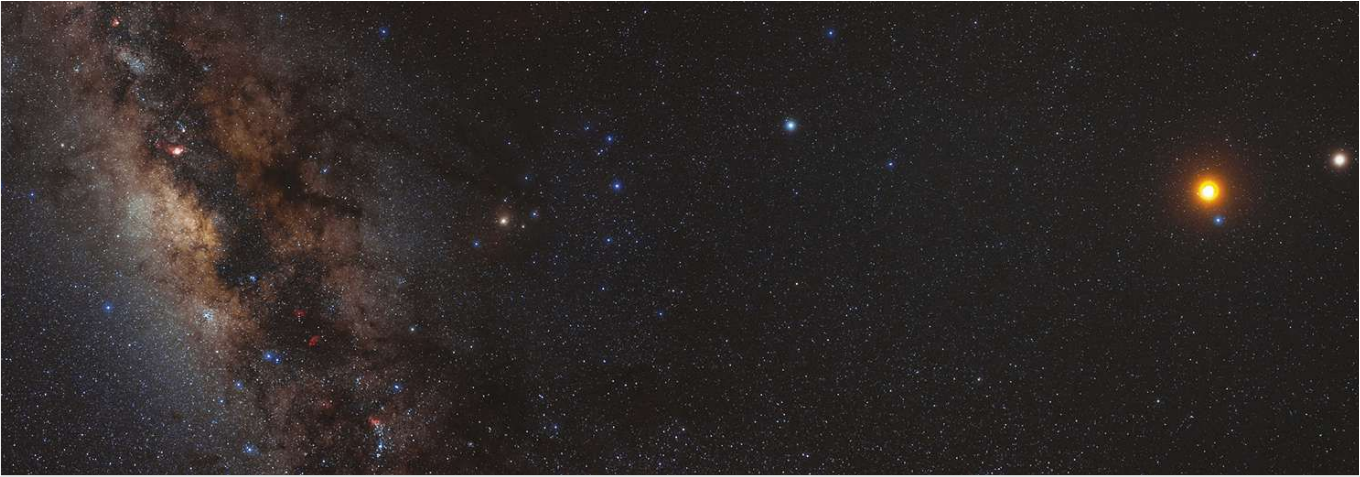
◀ Pluto's terrain

NEW HORIZONS SPACECRAFT, 10 DECEMBER 2015

New Horizons' flyby of Pluto has provided some amazing images of its surface. This section of Plutonian terrain was captured during the spacecraft's closest approach on 14 July 2015 and shows, left to right, the edge of Pluto's 'badlands' to the northwest of Sputnik Planum, across the al-Idrisi mountains, into the heart-shaped Tombaugh Regio and Pluto's icy plains.

YOUR BONUS CONTENT

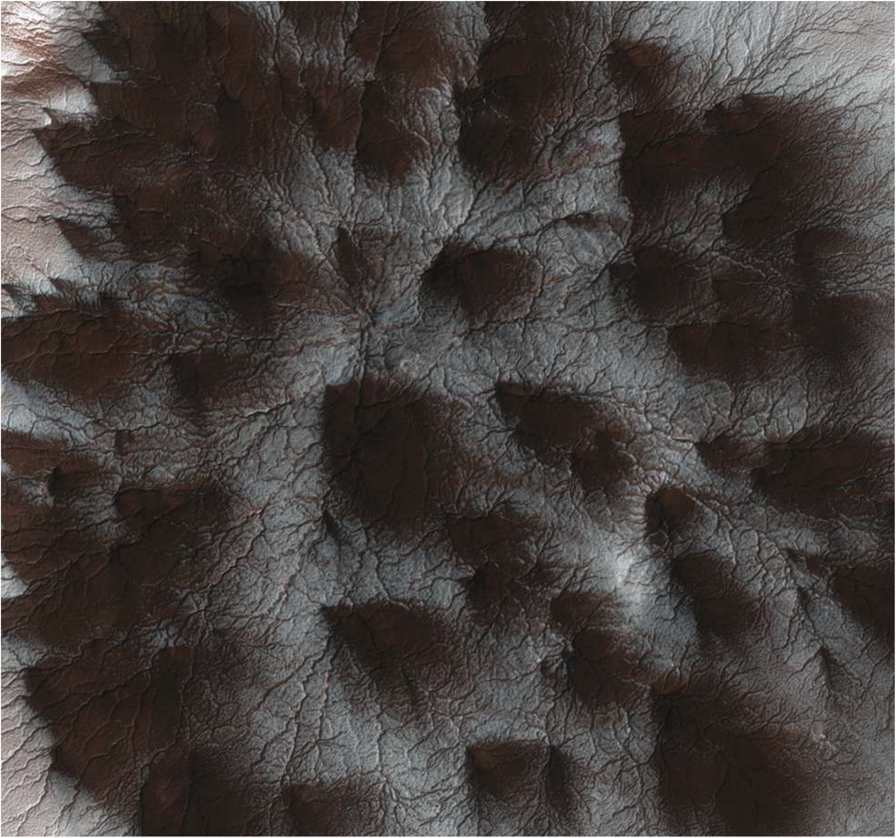
More stunning space images



▲ A red Moon and the Milky Way

BABAK TAFRESHI, 8 DECEMBER 2015

The dust lanes of the Milky Way are set against glistening blue stars in this image taken at ESO's La Silla Observatory. On the right, the orange-red glowing orb is in fact the Moon during a lunar eclipse. Normally the full Moon would drown out all but the brightest stars. During a lunar eclipse the Moon is a lot darker, so longer exposures reveal the beauty of the Galaxy and the Moon at the same time.



◀ Martian spring

MARS RECONNAISSANCE ORBITER, 11 JANUARY 2016

This curious image shows troughs on the surface of Mars, thought to be caused by gas flowing underneath carbon dioxide ice. The ice melts every Martian spring and sublimates into vapour. Gas that flows underneath the ice then escapes through small openings, causing these troughs to form, while the dust that spews out with the gas eventually falls back to the ground in dark deposits.

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Our experts examine the hottest new astronomy research papers

Does our Solar System have a ninth planet?

Simulations suggest a world between the size of Earth and Neptune lurks in the Kuiper Belt

A NINTH PLANET has been predicted in the outer regions of our Solar System. The hypothetical planet, inferred from simulations, would be around 10 times the mass of Earth and orbit at a distance 20 times that of Neptune. If found, the planet could solve several mysteries about our home in space.

"One of the most startling discoveries about other planetary systems has been that the most common type of planet out there has a mass between that of Earth and that of Neptune," says Konstantin Batygin from the California Institute of Technology. "Until now, we've thought that the Solar System was lacking in this most common type of planet. Maybe we're more normal after all."

The prediction was made by Batygin and his colleague Mike Brown while attempting to explain the odd behaviour of several Kuiper Belt Objects, or KBOs, with orbits that seemed to be aligned with each other. The chance of such an alignment happening randomly is only 0.007 per cent.

Simulations suggest that the presence of a ninth planet offered the best explanation – and also account for the orbit of the dwarf planet Sedna, which, unlike most other KBOs does not pass close to Neptune at any point in its orbit. Unexpectedly, the simulations also predicted KBOs with orbits inclined perpendicularly to the plane of the planets.

"Suddenly I realised there are objects like that," says Brown. "We plotted up the positions of those objects and their orbits, and they matched the simulations exactly."

▸ See Comment, below

The hypothetical planet is thought to be gaseous, similar to Neptune or Uranus

COMMENT
by Chris Lintott

As yet, Planet Nine is nothing more than a glint in astronomers' eyes, but if it is found it would be wonderful, the discovery of the century. What's more exciting is that its existence could be tested indirectly too, by exploring the Kuiper Belt a little further.

Good scientific theories need to be able to be falsified, and that's easy to do here. Go find a very, very large telescope and look for more objects in the outer Kuiper Belt. If most of them have orbits which are aligned with those of the objects we already know, then that adds to the evidence for the planet. If they're randomly scattered, then we've been deceived by picking patterns out of insufficient data – a speciality of the hyper-sensitive human pattern recognition system.

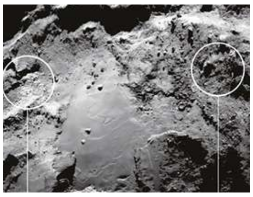
The nice thing about this is that in either case we will learn more about the Kuiper Belt, planet or no planet. You can bet there will be plenty of people searching.

CHRIS LINTOTT co-presents *The Sky at Night*

NEWS IN BRIEF

COMET 67P HAS ICE ON SURFACE

Though comet 67P/Chruyumov-Gerasimenko is surrounded by a halo of water vapour, most of this is thought to come from under the surface, since little exposed ice has been found on the comet's crust. However, infrared observations of the comet's top layer by Rosetta's VIRTIS instrument have shown a small amount of water-ice is mixed in with its organic-rich material.



THE LONELIEST PLANET WITH A PARENT STAR

Until recently astronomers thought that the planet 2MASS J2126 was floating freely across the Galaxy, but it now seems it is orbiting a star at a colossal distance: 1 trillion km, or 7,000 times the Earth-Sun distance. Scientists at the University of Hertfordshire realised that the planet is moving through space at a similar speed to nearby star TYC 948-927-1, suggesting the two are associated. If so, it is the widest star-planet system found. "The planet is not quite as lonely as we first thought, but it's certainly in a very long distance relationship," says lead author Dr Niall Deacon.

ESA/ROSETTA/NAVCAM – CC BY-SA IGO 3.0, UNIVERSITY OF HERTFORDSHIRE/NEIL COOK, BEIJING PLANETARIUM/JIN MA, ESA/NASA, ISTOCK, © ALEX CHERNEY

HUGE, POWERFUL POTENTIAL SUPERNOVA FOUND

The cosmic explosion may be the most powerful that has ever been seen

A BALL OF gas as bright as half a trillion Suns has been seen over 3.8 billion lightyears away and appears to be powered by an object only 16km across. Researchers believe that it is the result of a supernova – if they are right, it is the most powerful supernova ever seen.

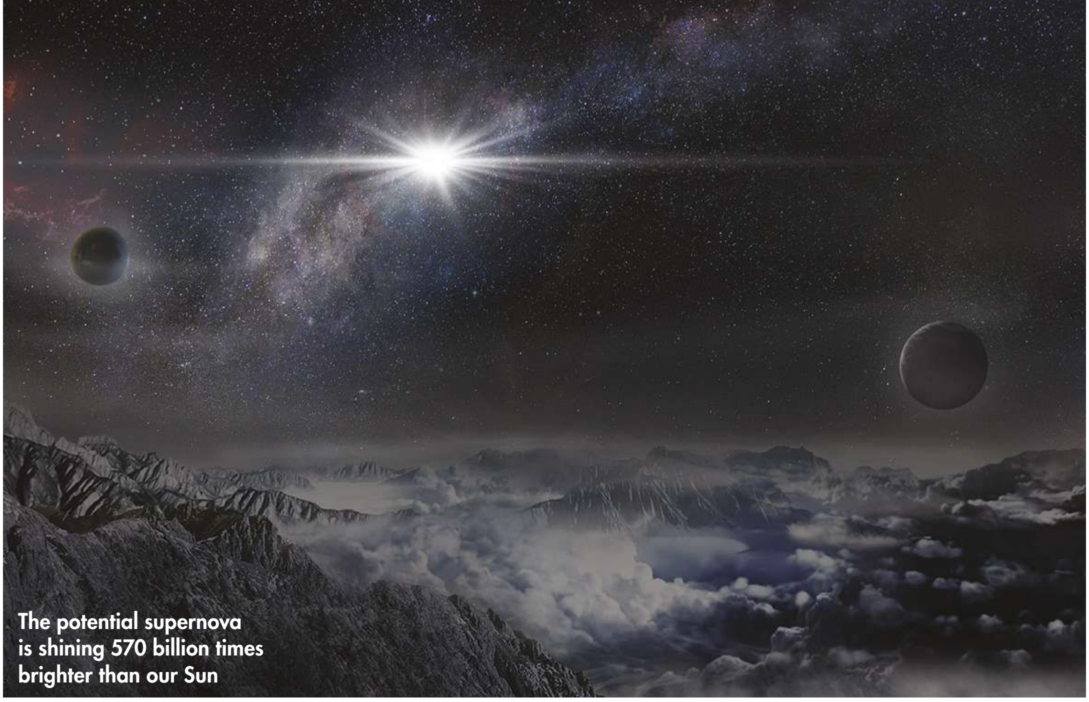
The mystery body, designated ASASSN-15lh, was found by the All Sky Automated Survey for Supernovae (ASASSN). At its centre may be a magnetar, a type of neutron star with an incredibly strong magnetic field. But if it is indeed a magnetar, its enormous output pushes the energy limits allowed by our current understanding of physics.

If ASASSN-15lh is a supernova remnant, then the explosion that powered it would have been 200 times more powerful than the average supernova, and 20 times brighter than all the stars in the Milky Way put together. "We have to ask, how is that even possible?" says Krzyztof Stanek, professor of astronomy at Ohio State University. "It takes a lot of energy to shine that bright, and that energy has to come from somewhere."

What could be powering the outburst is unknown. One possible explanation could be that the supernova created an extremely rare, rapidly spinning millisecond magnetar. To explain the observations it would have to be spinning over 1,000 times per second and convert this energy to light with near 100 per cent efficiency.

"Given those constraints, will we ever see anything more luminous than this?" says Todd Thompson from Ohio State University. "If it truly is a magnetar, then the answer is basically no."

However, another explanation is that the object is not a magnetar at all. Later this year, the Hubble Space Telescope will look at the galaxy that hosts ASASSN-15lh. If it lies at the centre, then the object may turn out to be some unusual activity around a supermassive black hole. Even so, this too would be something never seen before.
www.astronomy.ohio-state.edu



The potential supernova is shining 570 billion times brighter than our Sun

Tim Peake's spacewalk success

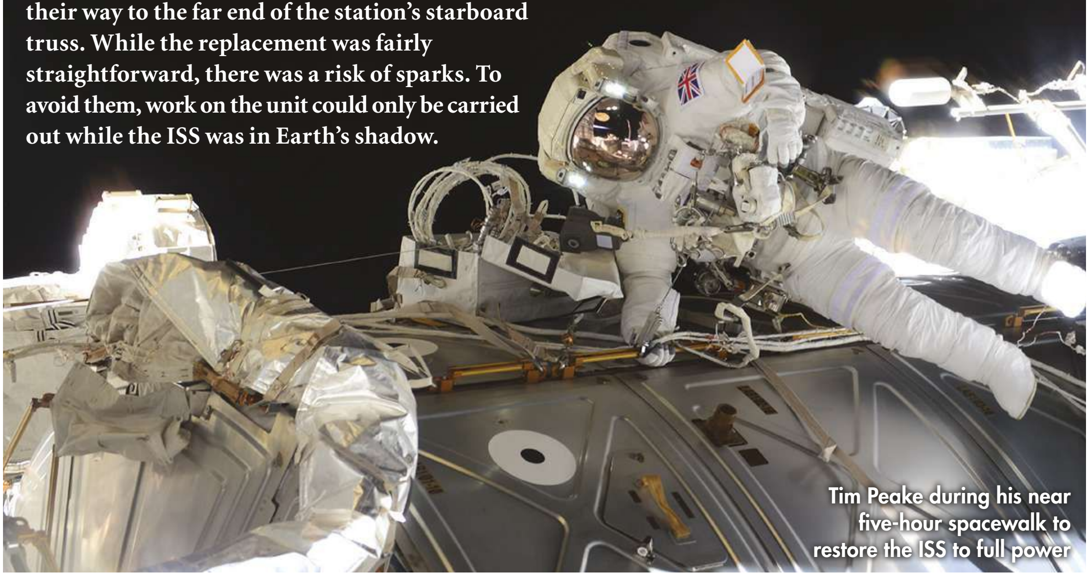
The EVA restores the ISS to full power, but Kopra suffers a helmet leak

BRITISH ASTRONAUT TIM Peake successfully completed a spacewalk with NASA colleague Tim Kopra on 15 January 2016 to repair a failed power regulator, which had reduced power on the International Space Station by an eighth.

The EVA, as spacewalks are officially known, began at 12:48 UT, and the pair quickly made their way to the far end of the station's starboard truss. While the replacement was fairly straightforward, there was a risk of sparks. To avoid them, work on the unit could only be carried out while the ISS was in Earth's shadow.

They completed this main task without incident. Afterwards, Peake installed new cables for the docking system, but a water build-up in fellow astronaut Tim Kopra's helmet forced mission control to end the spacewalk early, after four hours and 43 minutes.

https://principia.org.uk



Tim Peake during his near five-hour spacewalk to restore the ISS to full power

JOIN THE PROXIMA PLANET HUNTERS

THE SCIENTISTS SEARCHING for a planet around our nearest star, the 4.24-lightyear-distant Proxima Centauri, are inviting the public to find out how they're doing it. Previous observations of Proxima have given a tantalising hint of an Earth-like orbiting planet, but have not provided a definitive detection. The team will observe the star with the HARPS instrument on ESO's La Silla 3.6m Telescope, searching for the 'wobble' that betrays the presence of a planet. Additional nightly observations of the star by other telescopes will help researchers decide if any wobble seen is indeed a planet, or is due to variations on the star's turbulent surface.

During the search, researchers will post regular updates on a blog and social media, giving the public a chance to follow how modern astronomy is done. "We are taking a risk to involve the public before we even known what the observations will be telling us," says project coordinator Guillem Anglada-Escude. "We want to share the excitement of the search with people and show them how science works behind the scenes."

https://palereddot.com

The constellation of Centaurus hangs above the 3.6m Telescope at La Silla Observatory in Chile

NEWS IN BRIEF

LOFAR EXTENDS TO IRELAND

The world's largest radio telescope is about to become even larger. A new station for LOFAR (the Low-Frequency Array for Radio Astronomy) will be built at Birr Castle in Ireland, home to Lord Rosse's famous Leviathan of Parsonstown, in 2016.

The Irish antenna will join 50 already spread across Europe and extend the LOFAR network to 2,000km. "Such long distances allow exquisitely finely detailed sky imaging capability," says Dr Rene Vermeulen, director of the International LOFAR Telescope.

DARK 'NOODLES' MAY SPAN THE GALAXY

The shape of 'lumps' in the Milky Way's interstellar gas may have been found for the first time. The invisible objects, around the size of the Earth-Sun orbit, were observed with the Australia Compact Array radio telescope.

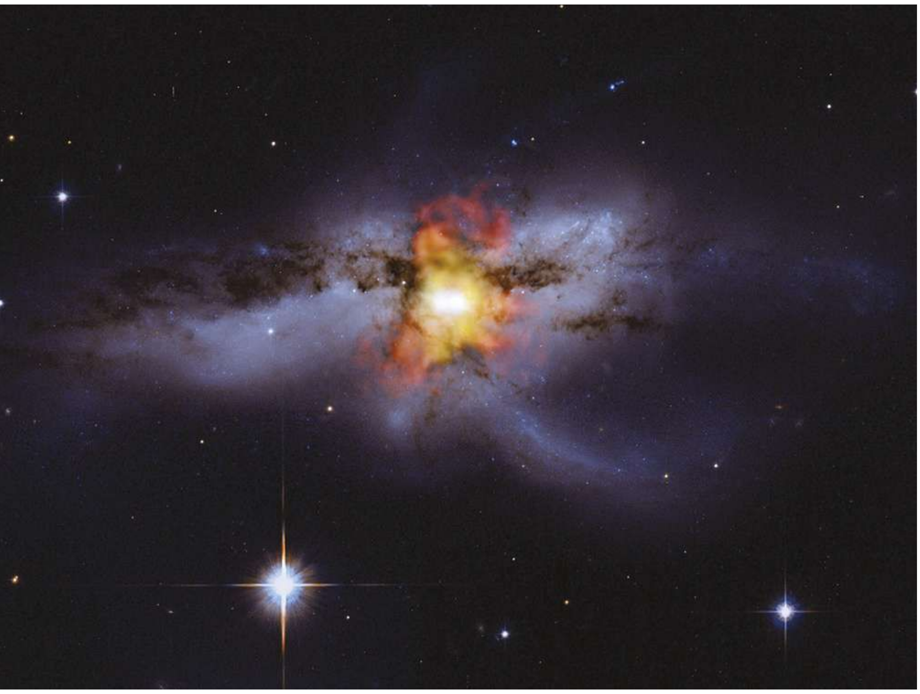
"We could be looking at a flat sheet, edge on," says Dr Cormac Reynolds, a member of the team who made the discovery. "Or we might be looking down the barrel of a hollow cylinder like a noodle, or at a spherical shell like a hazelnut."

CUTTING EDGE

Our experts examine the hottest new research

A butterfly on the wind

The result of two merging galaxies, NGC 6240 is home to some extreme winds



▲ **The black holes of this interacting system, the bright point in the centre, are 3,000 lightyears apart; it will be tens of million of years before they merge**

X-RAY: NASA/CXC/MIT/C.CANIZARES/M.NOWAK; OPTICAL: NASA/STSCI

NGC 6240 is a fabulous train wreck of a galaxy, the result of an ongoing merger between two large spirals, and it's not surprising that it's been studied by pretty much every telescope or instrument built in the past few decades. And it isn't just the colliding galaxies themselves that attract attention; the system is embedded in a nebula of gas which extends more than a hundred thousand lightyears from the centre.

Understanding the structure of the gas in this nebula is key to understanding the history of the system as a whole. In this month's paper the researchers make use of the spectacular Suprime-Cam, now installed on the 8m Subaru Telescope on Mauna Kea in Hawaii. The observations focus on light emitted by hydrogen and nitrogen. Such narrowband imaging, similar to the use of a nebula filter by astrophotographers, allows the details of the surrounding nebula to be seen for the first time.

Even a first glance at the resulting images shows the complexity of the structure. At the centre is an extended structure which the paper's authors describe as a butterfly. Surrounding that, there is a bright hourglass of gas, which is in turn embedded in a fainter, irregularly shaped cloud. This larger cloud is streaked with filaments, signs of interaction with the galaxies at the structure's heart, and things are made more complicated by the discovery of faint bubbles, tens of thousands of lightyears across to both the southeast and the northwest of the galaxy.

It may be faint, but all of this structure is significant – the authors reckon that there is something like 500 million solar masses worth of gas in the system. The best explanation for how it got there is that it's the result of a powerful wind being driven by merger-triggered star formation in the two galaxies. Such a wind, like the more famous example seen emanating from M82, would 'blow' the observed bubbles, and contribute to the reservoir of gas surrounding the galaxies. It might even, through collisions, excite the gas, causing the bright ultraviolet and X-ray emissions that have been observed.

For this to be true, the wind must be blowing pretty strong – velocities of up to 500km/s have been observed. Such rapid speeds mean that the structures we see must have formed recently, and the authors conclude that the outer regions of the nebula formed within the past hundred million years. At that time, a major starburst – a period of rapid star formation – must have been underway, with further bursts of star formation occurring 20 million years ago to form the hourglass and eight million years ago to form the butterfly.

> "Such rapid wind speeds mean that the structures we see must have formed recently"

It's remarkable that we're able to understand the history of such a system in such amazing detail. There are further mysteries to be explored, in particular the role the fall of material onto the central black holes of the two galaxies plays in shaping the inner regions of the nebula, but NGC 6240 is already providing insights that will help astronomers unpick the history of more distant, less well-known systems.

CHRIS LINTOTT is an astrophysicist and co-presenter of *The Sky at Night* on BBC TV. He is also the director of the Zooniverse project.

CHRIS LINTOTT was reading… *Giant Hα nebula surrounding the starburst merger NGC 6240* by Michitoshi Yoshida et al **Read it online at http://arxiv.org/abs/1512.09208**

NEWS IN BRIEF

THE MISSING LINK OF BLACK HOLE EVOLUTION?

A rare intermediate black hole may have been detected, the missing link between 'stellar mass' black holes and the supermassive monsters that lurk in the hearts of galaxies. Its presence was suggested to explain the unusual movements of gas in a cloud 200 lightyears away, which implied the presence of a massive body – though none could be seen. Simulations suggested an object with 100,000 times the mass of the Sun might be responsible. It's thought that supermassive black holes grow from mergers of smaller objects, but so far no one has been able to spot this intermediate step.

FLOWERS BLOOM IN SPACE

Astronauts on the ISS have grown the first flower as part of the VEGGIE experiment, to test how plants develop in microgravity as a prelude to future deep-space missions. The edible orange zinnia, a relative of the sunflower, was planted late last year.

TOMOCHARU/KEIO UNIVERSITY, NASA X 2, NRAO/AUI/NSF/DANA BERRY/
SKYWORKS/ALMA (ESO/NAOJ/NRAO), © SPUTNIK/ALAMY STOCK PHOTO

Luminous galaxy shreds itself

Turbulent gases powered by a black hole are wreaking havoc

▲ **It is likely that the galaxy will eventually blow away all the gas and dust surrounding it, leaving a quasar**

THE MOST LUMINOUS galaxy in the known Universe is ripping itself apart. The huge luminosity of W2246-0526 seems to stem from its central black hole, which churns up surrounding matter. The friction from this heats the gas until it glows with the brightness of 300 trillion Suns.

While other galaxies undergo a similar process, the activity is usually confined to a specific region. Here it is spread across the whole galaxy.

"The momentum and energy of the particles of light deposited in the gas are so great that they are pushing the gas out in all directions," says Roberto Assef, an astronomer with the Universidad Diego. "This galaxy is tearing itself apart."
http://www.nasa.gov/wise

'GREEN PEAS' SOLVE REIONISATION RIDDLE

NEWLY FORMED DWARF galaxies are likely to have been responsible for the reheating of the Universe 13 billion years ago. Scientists have long thought that galaxies were the cause of this event, known as the cosmic reionisation, but fresh evidence has emerged in the form of observations of green pea galaxy J0925+1403. It's thought that forming galaxies emit high levels of ionising radiation, and that most of it is absorbed by gas and dust before it escapes. But J0925+1403 is ejecting its ionising photons at greater intensity than ever seen before.

"This galaxy appears to be an excellent local analogue of the numerous dwarf galaxies thought to be responsible for the reionisation," says Trinh Thuan of the University of Virginia.
http://hubblesite.org

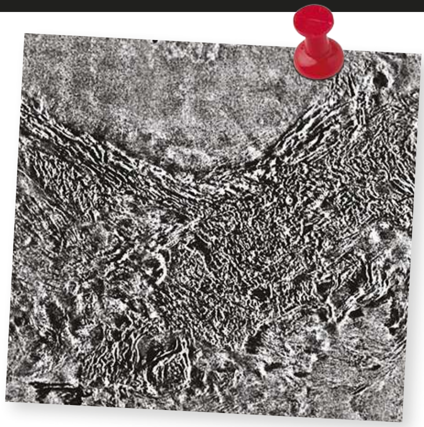
Green pea galaxy J0925+1403 – these galaxies are so named as they appear green, round and compact

Looking back The Sky at Night

March **1984**

The *Sky at Night* episode broadcast on 11 March 1984 looked at how the Venera 15 and 16 probes were mapping the surface of Venus. The probes used radar to pierce the planet's thick carbon dioxide atmosphere. Over a period of eight months, the probes created a map with a resolution of 1-2km, revealing a landscape that had been ravaged by volcanism. Over 80 per cent of the surface was covered in volcanic plains but there was little evidence of the lava flows or caldera that should have gone with them.

These maps were improved upon by NASA's Magellan Orbiter, which reached the planet in 1990 and eventually created a radar map with a resolution of 100m, revealing the planet's surface to be less than 800 million years old. In 2005, infrared and gravitational measurements made by ESA's Venus Express revealed evidence of active volcanism on the planet.



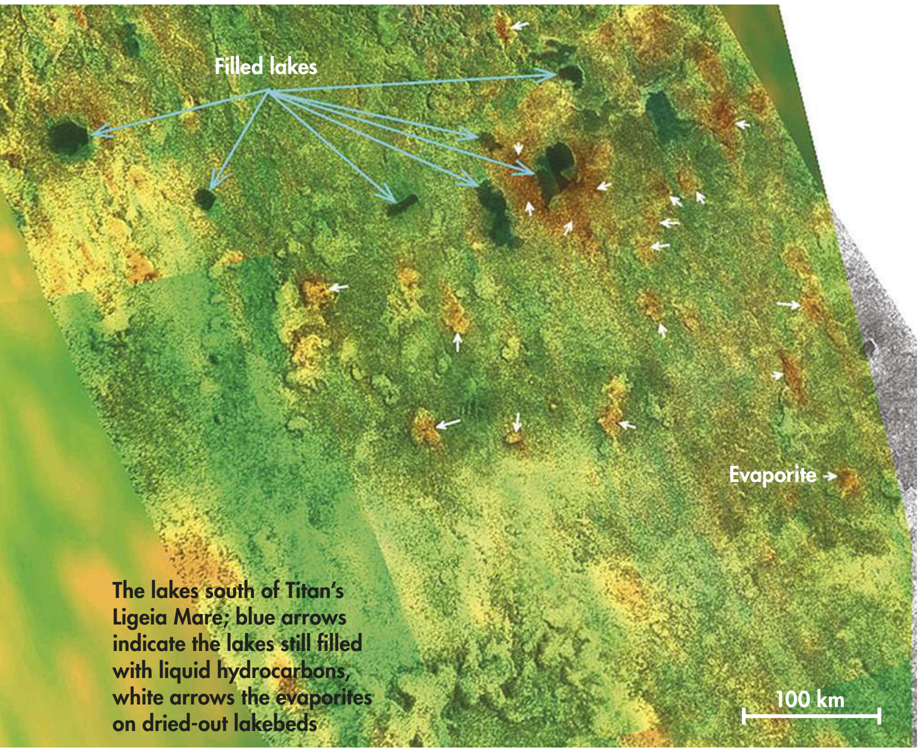
▲ **Part of a Venus radar map, made with images from Venera 15 and 16**

CUTTING EDGE

Our experts examine the hottest new research

Titan's exploding salt flats

Looks can be deceiving: though this moon of Saturn bears similarity to Earth, its chemistry is vastly different



The lakes south of Titan's Ligeia Mare; blue arrows indicate the lakes still filled with liquid hydrocarbons, white arrows the evaporites on dried-out lakebeds

Titan presents something of a conundrum to planetary scientists. We've been getting to know the surface features of this mysterious moon pretty well over the past decade, with repeated flybys from Cassini and the close-up look afforded by the Huygens lander. Geomorphologically this giant moon is strongly reminiscent of Earth: a landscape of mountains, plains, river valleys and lakes. But when you consider the chemistry of the moon's surface you realise just how truly alien it really is.

Titan's hydrological cycle – lakes, rivers, clouds and rain storms – is composed not of water but liquid ethane and methane. And these liquid hydrocarbon lakes and seas would have a load of organic molecules dissolved in them, just as the liquid water oceans of Earth hold dissolved salts. When terrestrial seas dry out, they leave behind playas, flats encrusted with thick deposits of the once-dissolved solutes. These are known as evaporite deposits, such as the white salt flats of Bolivia. And exactly the same basic physical process would be expected on Titan.

NASA/JPL/UA

LEWIS DARTNELL is an astrobiologist at the University of Leicester and the author of *The Knowledge: How to Rebuild our World from Scratch* (www.the-knowledge.org)

Daniel Cordier and colleagues describe how, as a hydrocarbon sea evaporates away on Titan, the difference in solubility of these organic compounds in the remaining solvent means that a succession of layers would be deposited; the least soluble settling first onto the bottom and the most soluble finally precipitating on top. But it's largely unknown what the exact chemical composition and layering of these evaporite deposits would be. So to explore this, Cordier and team combined lab experiments with a computer model of the process.

Their first finding agrees with what had been previously suspected, that the major evaporite deposit on the surface would be a mixture of acetylene and butane; an exotic blend that on Earth (with our oxygen-rich atmosphere) would be dangerously explosive. Just let that settle in: Titan has 'salt flats' made up of an evaporitic crust of frozen welder's torch gas.

And because of that sequential precipitation process of the dissolved compounds, Cordier predicts that as lakes and seas on Titan dry out they would leave behind 'bathtub rings' of evaporite deposits. Acetylene and butane, as the most soluble components, would form in the middle as the last dregs of the lake evaporated, with a surrounding rim of hydrogen cyanide, and perhaps an outer scum mark of organic molecules called tholins that had precipitated down from the atmosphere.

> "As Titan's lakes and seas dry out they may leave 'bathtub rings' of evaporite deposits"

One puzzle of the evaporite deposits we've spotted from orbit is that they're very radar-reflective – they appear bright in Cassini's radar images. This could be due, says Cordier, to the crystal structure of evaporite acetyle and butane on the surface. Either way, these evaporite deposits in dry lakebeds offer superb landing sites for future Titan probes – armed with a drill, such a lander could explore down through the chemical complexity of the moon's surface, all naturally concentrated by evaporation.

LEWIS DARTNELL was reading… *Structure of Titan's evaporites* by D Cordier et al
Read it online at http://arxiv.org/abs/1512.07294

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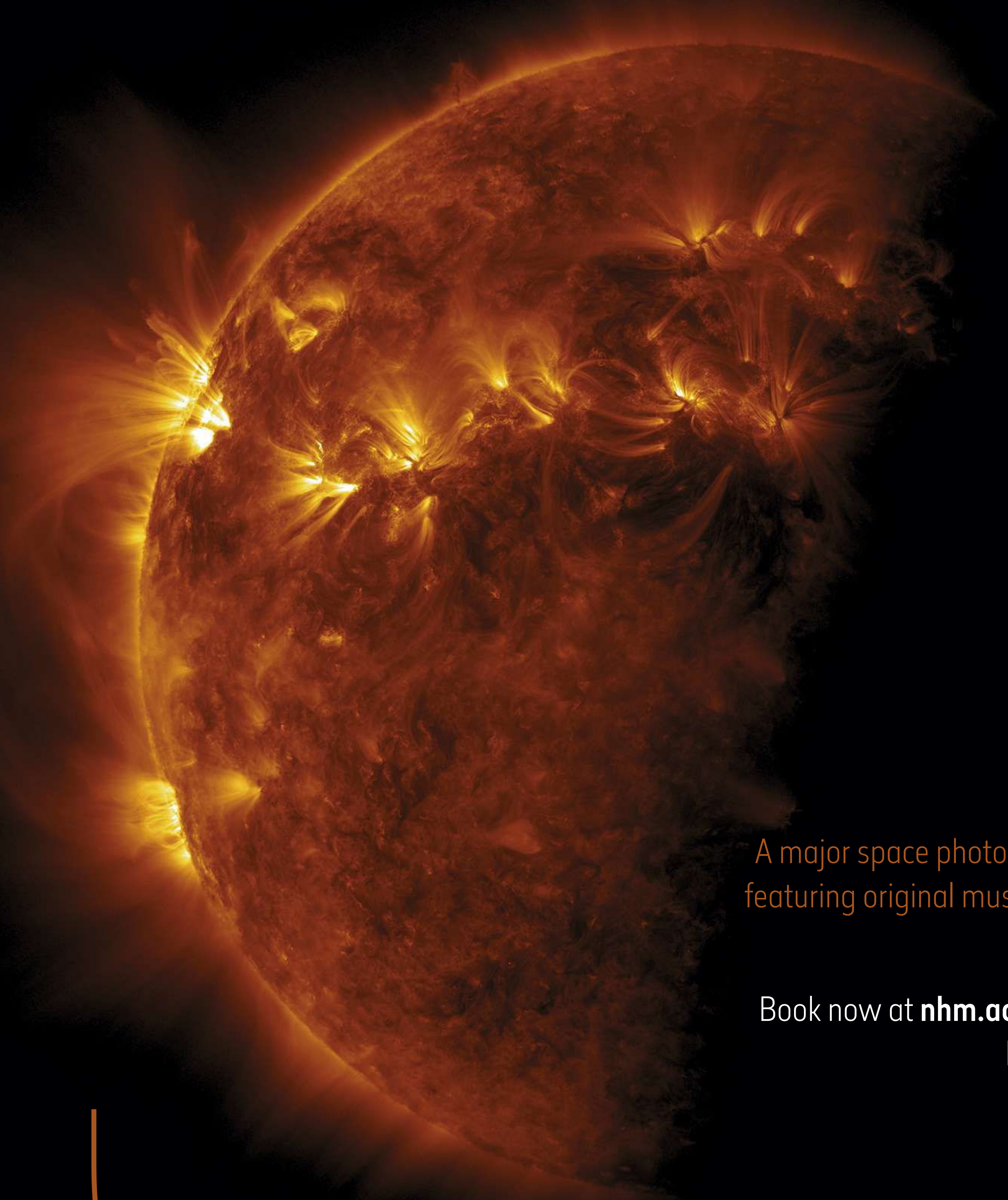

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What's on

Our pick of the best events from around the UK

British Science Week

Across the UK, 11-20 March

PICK OF THE MONTH

▲ Celebrate science and astronomy in your community during British Science Week

British Science Week is a 10-day celebration of science, technology, engineering and maths involving schools, clubs and communities. Organised by the British Science Association, last year the programme saw over 5,000 events attended by some 1.6 million participants.

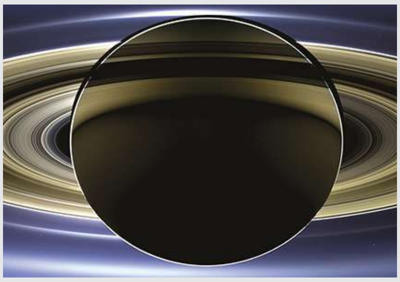
It returns this month with a range of talks, demonstrations and citizen science projects taking place across the UK. The programme for 2016 features numerous astronomy events such as stargazing sessions under dark skies in Wales, a public tour of Glasgow Observatory, pop-up planetariums, science fairs, lectures, astronomy festivals and many other space-related activities across the UK for young and old, experts and amateurs alike.

You can also organise an activity or event of our own, with free support and resources available from the British Science Association to help with planning. Go online for more information about the programme and to find out what's happening near you.
www.britishscienceweek.org

BEHIND THE SCENES

THE SKY AT NIGHT IN MARCH

BBC Four, **13 March**, 10pm (first repeat BBC Four, **17 March**, 7.30pm)*



This of shot Saturn by Cassini in 2013 is one of the five – find out why in the show

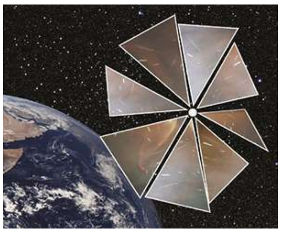
THE FIVE GREATEST IMAGES OF THE SOLAR SYSTEM

The team choose the five most important pictures ever taken of the Solar System. From the most detailed picture of Saturn's Rings, to real time images of the Sun and a close-up of the Martian surface, these are the photos that have transformed our view of our pocket of space.

**Check www.bbc.co.uk/skyatnight for subsequent repeat times*

Solar Sails: A Glimpse of the Future?

Hampshire Astronomical Group, Clanfield Memorial Hall, Clanfield, 11 March, 7.30pm



Solar sails continue to attract attention from both space agencies and the private sector. In this talk Dr Thomas Waters of the University of Portsmouth explains the solar sail concept, its sustainable, fuel-free form of travel and how it might be used in the future. Admission is £3 for non-members.
www.hantsastro.org.uk

A Rosetta Update

The British Geological Survey, Keyworth, Nottingham, 3 March, 7.30pm

Dr Colin Snodgrass of the Open University leads a consortium of astronomers who observe comet 67P/Churyumov-Gerasimenko from Earth in support of the Rosetta mission. In this talk hosted by the Nottingham Astronomical Society, he provides an update on the mission so far, revealing the latest results sent back to Earth. Admission is free.
www.nottinghamastro.org.uk

Life on Mars?

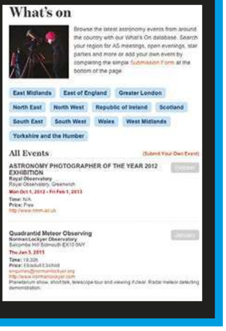
Northampton Natural History Society, The Humfrey Rooms, Northampton, 14 March, 7.30pm

What connects the microbiology of salt mines with the potential for life on the Red Planet? Open University PhD student Peter Woolman looks at the search for life in the Solar System, and how salt-loving microorganisms called halophiles could reveal the secrets of Martian life. Admission is free.
www.nnhs.info

MORE LISTINGS ONLINE

Visit our website at **www.skyatnightmagazine.com/whats-on** for the full list of this month's events from around the country.

To ensure that your talks, observing evenings and star parties are included, please submit your event by filling in the submission form at the bottom of the page.



What's on

Browse the latest astronomy events from around the country with our What's On database. Search your region for AS meetings, open evenings, star parties and more or add your own event by completing the simple Submission Form at the bottom of the page.

All Events (Submit Your Own Event)

ASTRONOMY PHOTOGRAPHER OF THE YEAR 2012 EXHIBITION
Royal Observatory
Royal Observatory, Greenwich
Mon Oct 1, 2012 - Fri Feb 1, 2013
Time: N/A
Price: Free

Quadrantid Meteor Observing
Norman Lockyer Observatory
Salcombe Hill Sidmouth EX10 0NY
Thu Jan 3, 2013
Time: 19:30h
Planetarium show, short talk, telescope tour and viewing if clear. Radar meteor detecting demonstration.

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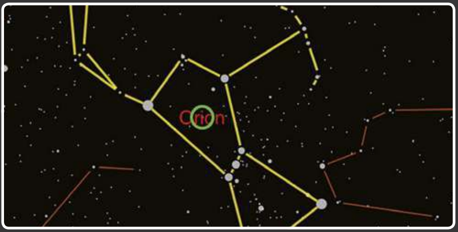

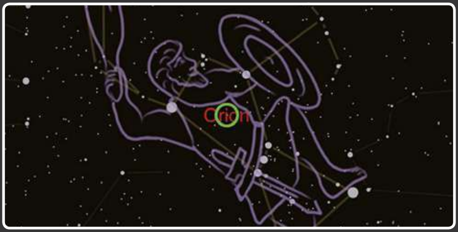

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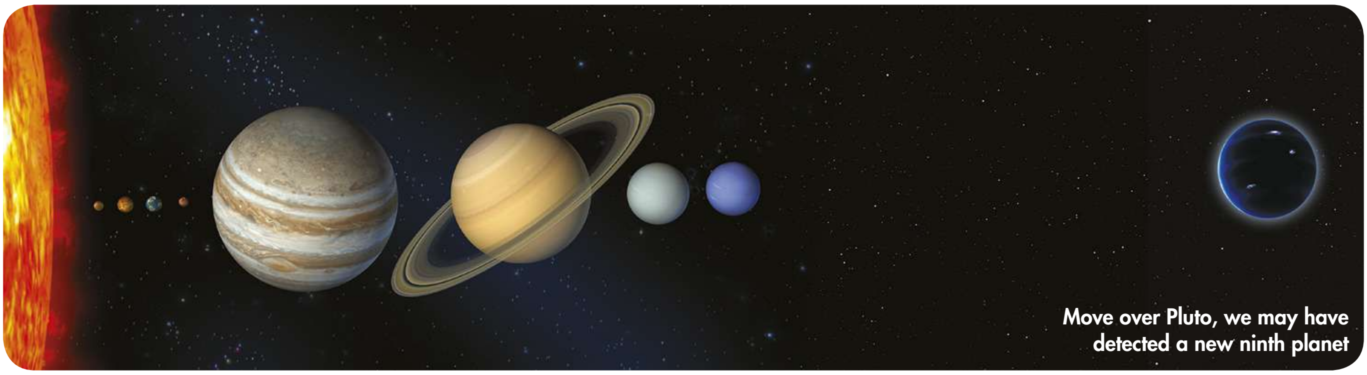
A PASSION FOR SPACE

with **Maggie Aderin-Pocock**

The Sky at Night presenter examines what we know about the Solar System's putative new planet



Move over Pluto, we may have detected a new ninth planet

A recent paper has suggested that there could be another planet orbiting the Sun in our Solar System. This new world has been dubbed Planet Nine, but what has been implied about it so far?

Here's the evidence for the presence of Planet Nine in the paper: it's a study of several Kuiper Belt Objects (KBOs) that shows the inclination of their orbits seems to be aligned to an extent that does not seem probable (only a 0.007 per cent chance) without the presence of a planet-sized body. Computer modelling can be used to predict what this body might be and where its orbit would sit, and the paper shows the results of the modelling.

It's thought that Planet Nine has a mass around 10 times that of Earth, putting it into a category we call super-Earths. Studies of confirmed exoplanets found to date show this to be the most numerous size of exoplanet – 85 per cent of them fall into this size category.

The putative planet sits a long way from the Sun in a very elliptical orbit. Its closest approach to our star (perihelion) is estimated to still be a whopping 200 AU away, the farthest point (aphelion) 1,200 AU. The planet's orbit is also thought to be steeply inclined, by as much as 30° off the elliptic. Its orbital period is estimated at 10,000 to 20,000 years.

Has it always been there?

It is unlikely that Planet Nine formed in its currently proposed position. It would take longer than the age of the Solar System for a planet of this size to form due to the conglomeration of smaller objects. A more likely scenario is that the planet formed closer to the Sun but was then thrown outwards due to the interaction of the larger planets of the Solar System.

Modelling has shown that for this theory to hold, other larger, star-sized bodies would need to be in proximity to our Sun, to stop Planet Nine from flying out into the Galaxy. This idea, of the Sun being born in a cluster of local stars, is one that has been around for a while.

What evidence do we need to confirm its existence? A sighting would great but this may prove to be difficult. Although Planet Nine's 10 Earth masses is sizeable, it sits a long way out and direct viewing is likely to depend on which part of its orbit it is in. However, other evidence can be found in the movement of objects in its surrounding area, even ones as small as the New Horizons spacecraft.

When are we likely to get confirmation one way or the other? If it is out there, this may again depend on which part of its orbit it is in.

Telescopes across the world are now joining the search so hopefully we could see a result in the next five to 10 years. For now the jury is out on Planet Nine, but what really excites me is that there is potentially a lot more to find out about our Solar System, and that looking at planets orbiting distant stars can help us understand what is happening around our own.

Maggie Aderin-Pocock is a space scientist and co-presenter of *The Sky at Night*

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JON CULSHAW'S EXOPLANET EXCURSIONS

Jon sets his sights on a moon without a sunrise, orbiting a gas giant without a star

I've always been fascinated by drifting planets with no connection to their parent stars. They've a mystique and a sense of defiant non-conformity I find appealing. I imagine them to be like William Hartnell's Doctor in *Doctor Who*, refusing to fall in with regular Solar System patterns like orbits in all their looping, repetitive predictability.

One of the strangest unconnected planets of this kind lies in the Beta Pectoris Moving Group – a collection of objects sounding like a celestial travelling band led by a Jeff Lynne of the far future.

In 2013 astronomers from University of Edinburgh observed this intriguing detached world 75 lightyears away. The planet, named PSOJ3185-22, was found to be immensely hot despite the absence of a home star: a young, Jupiter-sized gas giant with many layers of both thick and thin clouds. The temperatures existing deep within these clouds, composed most likely of molten iron droplets, are estimated to reach around 800°C.

Solar Systems in their formative phases can be unstable and violent. Perpetual meteor bombardments and colliding objects create chaotic scenes reminiscent of a mass custard pie fight. Planetary collisions and gravitational tussles can result in entire planets being ejected from their systems, as if they were in sumo tournaments of cosmic proportions.

This stray world would make a spectacular vision close up, so I steer the Perihelion to observe events as closely as possible. Luckily there are many irregular moons orbiting around this shimmering gas giant. Their varying shapes, similar to Phobos and Diemos around Mars, mean they are likely to be asteroidal objects captured into orbit around the planet and then heaved out of the system along with it.

The orbiting object I'm headed to is about 25km wide and brings to mind the asteroid that curtailed the reign of the dinosaurs 65 million years ago. This little moon lies in such a close orbit that from it the wandering parent planet appears to rise and set at inconceivable speed, similar to the pace we see the ISS crossing west to east in Earth skies. Black sky yields to a penumbral glow of dense purple and ochre just before the planet rises triumphantly, invading the sky and powering through it. The smattering of unfamiliar constellations are instantaneously washed out by the spectacular brooding glow of the molten iron cloud layers.

It's an awe inspiring view, like a spherical volcanic eruption bulldozing through this alien sky. The Perihelion's orbital readers show the path of this moon on which we're parked is decaying.

Thankfully there's no urgent need to flee the scene as it'll be 3.7 million years until the parent planet's gravity shreds it into fragments, fragments that will add extra substance to the molten iron clouds of the planet. There'll be many more chances to observe the incredible vision of planet rise and planet set before needing to flee the Beta Pectoris Moving Group for our next destination.

Jon Culshaw is a comedian, impressionist and guest on *The Sky at Night*

MAIN ILLUSTRATION: MARK GARLICK, SPACECRAFT: PAUL WOOTTON, PHOTO: EMMA SAMMS

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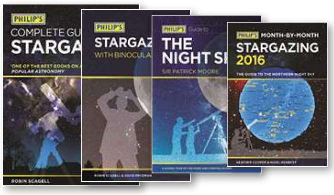
This month's top prize: four Philip's books

The 'Message of the Month' writer will receive four top titles courtesy of astronomy publisher Philips: Robin Scagell's *Complete Guide to Stargazing*, Sir Patrick Moore's *The Night Sky*, Robin Scagell and David Frydman's *Stargazing with Binoculars* and Heather Couper and Nigel Henbest's *Stargazing 2016*



SOCIAL MEDIA

WHAT YOU'VE BEEN SAYING ON TWITTER AND FACEBOOK

Have your say at **twitter.com/skyatnightmag** and **facebook.com/skyatnightmagazine**

@skyatnightmag asked: Have you observed Jupiter yet this apparition? What changes have you noticed?

@Stephencheatley I spotted Callisto just leaving the right hand limb on Wednesday night, as the planet appeared close by our moon.

@sjb_astro Main bands looked darker to me on 27 Jan. I plan to do a few sketches this opposition so will compare with prev drawings.

@kezzaflipflop Just bought my 1st telescope today and waiting for some clear skies!

@remeus_romulus #Jupiter and satellite #Io on the edge.

MESSAGE OF THE MONTH

If only we could fix the weather...

◂ **Binoculars are a great purchase if you are starting out – there's no setting up and the gains are huge**

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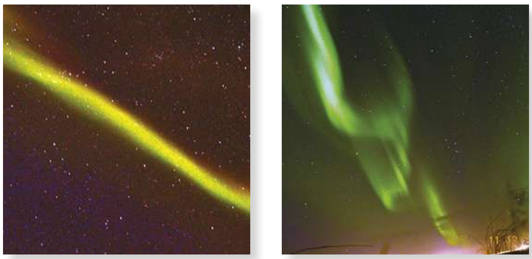
I have for many years been very interested in astronomy, but up until now my interest has been restricted to naked-eye astronomy, books and of course watching *The Sky at Night*. Now approaching retirement and with more time to devote to my interests, the opportunity has arisen to do more. After lots of head scratching I plumped for a set of binoculars rather than a telescope, the logic being that I could nip out with the binoculars for a quick look rather than setting up a telescope – at least that was the idea. Now that I'm the proud owner of a set of 25x80 astronomical binoculars, I've quickly realised how much a tripod helps! So there I am on New Year's Eve – the first clear night since I've had them – out looking with delight at the Orion Nebula, and I discover what can be achieved on photos of the Moon with a camera and image processing. I'm hooked! It's early days and I am sure my images could be so much better, but I've just taken delivery of a smartphone adaptor to fit the bins. Now all I need are some clear nights – and a telescope!

Steven Chambers, via email

I'm sorry we can't help with the weather or a scope, Steven, but I hope you find some new targets in the books that are on their way to you. ***– Ed***



▴ **Stephen's 5-second shots of the aurora over Iceland**

No mount, no problem

I thought I would get in touch to send these images of the aurora, mainly to show fellow readers that one doesn't always need specialised equipment to take astrophotos. The pictures were taken just outside Keflavík in Iceland with a Nikon D3200 DSLR camera on a 5-second exposure with a remote control shutter release and the camera laid facing up on a clump of grass. I am told the red parts are quite rare so I was very lucky to have captured them.

Stephen Whyles, Grantham

It's great to have captured those memories, Stephen. Do turn to page 66 to read more adventures to see the aurora. ***– Ed***

A shot in the dark

Listening to Chris Hadfield talk about the ISS at his quite superb presentation at Symphony Hall in Birmingham he referred to some of the problems encountered on the space station. One that affected Tim Peake's current mission was the docking problem between the Soyuz and the ISS. It made me think whether it could be technically feasible to have an 'electromagnetic harpoon' that can be switched on only when needed which, when fired from one to the other, is guaranteed to only mate in exactly the right place. It could have a light tether attached that could reel the Soyuz in on target every time. If the tether was a tube it could perhaps then be inflated to provide a stiffer and hence more controllable mechanism.

I recognise there are consequential issues to deal with – induced pitch and roll motion on the Soyuz for example – but I wonder if the mass of the ISS is actually sufficiently high in relation to that of the Soyuz capsule that these effects would be insignificant, or at least easily managed.

David Tart

An interesting idea, David. The severe weight restriction on any spacecraft might be another factor to take into consideration. ***– Ed***

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The perfect addition to your stargazing, *BBC Sky at Night Magazine* is your practical guide to astronomy, helping you to discover the night skies, understand the Universe around us and learn exciting techniques for using your telescope.

Impacts on Mars and other bodies in the Solar System can eject fragments of rock into space, some of which end up on our own planet

Messengers from the Solar System

There are samples of planets and other Solar System objects already here on Earth. **Will Gater** speaks to the scientists lucky enough to be working with them

If there's one thing that defines of Solar System science today, it's the scattering of robotic explorers we've sent out among the planets. Our emissaries have journeyed to to cratered asteroids, tumbling comets, the ochre plains of the Red Planet and many more besides.

Each probe and lander has been a proxy for the geologist's hand, reaching out toward an unknown world, or the scientist's eyes, contemplating an unexplored vista. Look at any spacecraft being assembled in a cleanroom and what you see in the instruments and cameras screwed to its frame is its earthbound science team's spirit of enquiry and curiosity brought into physical form.

At Mars today, NASA's Curiosity rover is exploring the dunes and outcrops of Gale Crater. Its more formal title – the Mars Science Laboratory – is a hint of the impressive range of scientific tools it's using on the Red Planet. And when ESA went to visit comet 69/P Churyumov-Gerasimenko with the Rosetta mission they sent a lander too, Philae, crammed with advanced instruments for studying the icy surface.

Delivering these miniature laboratories to their targets presented enormous technological challenges, but the potential rewards are immense. Being able to analyse the rocks, dust and soil of our planetary neighbours up close can help researchers answer some of the biggest questions in science today. Yet while these missions grab headlines around the world, few realise that there are already precious pieces of a select few Solar System bodies being scrutinised in laboratories right here on Earth.

Some of these rare samples we've collected ourselves on daring missions; some arrived ▸

ABOUT THE WRITER
Will Gater is an astronomy journalist, author and astrophotographer. Follow him on Twitter: @willgater

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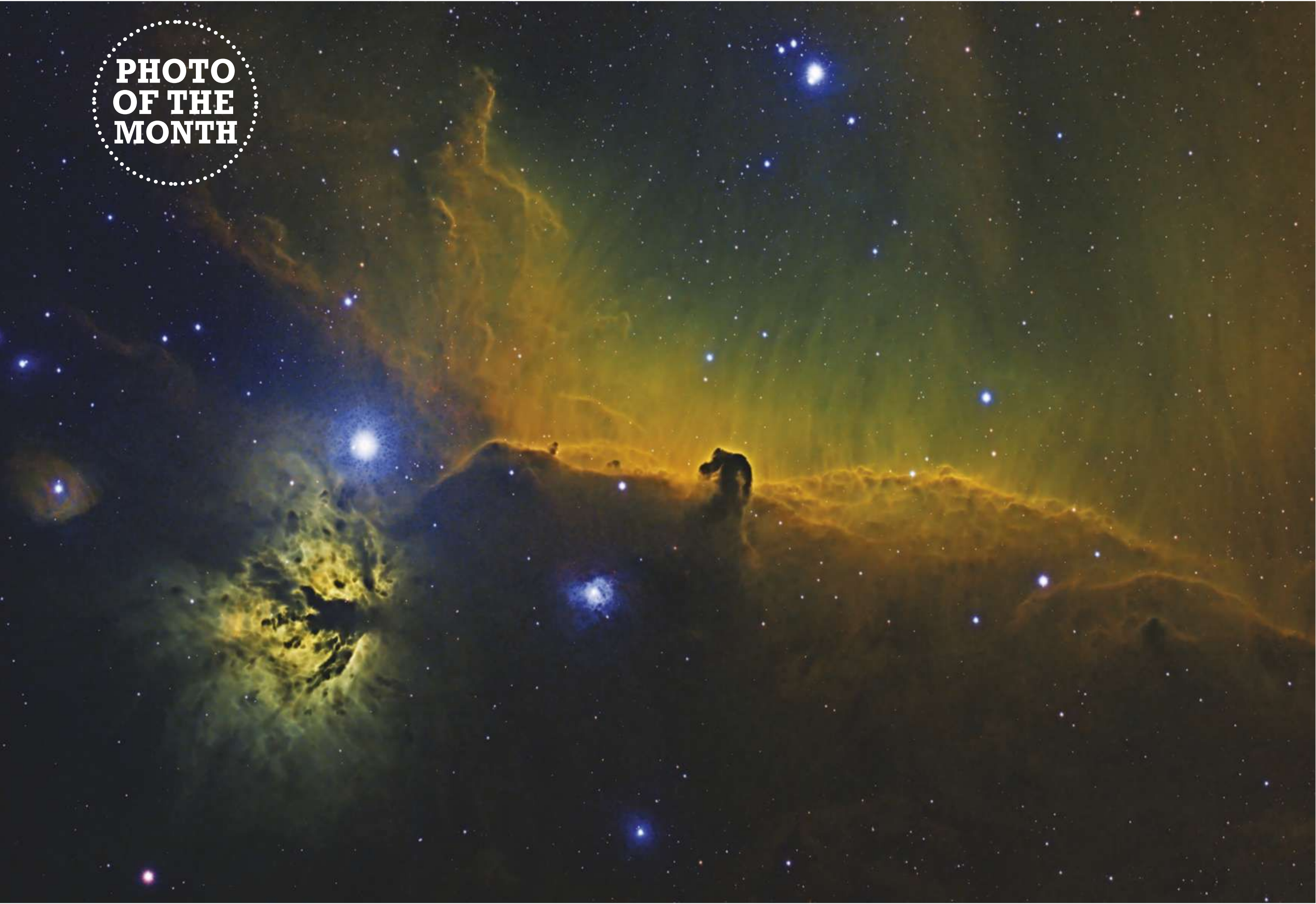
Hotshots

This month's pick of your very best astrophotos

YOUR BONUS CONTENT

A gallery containing these and more of your stunning images



▲ The Horsehead Nebula

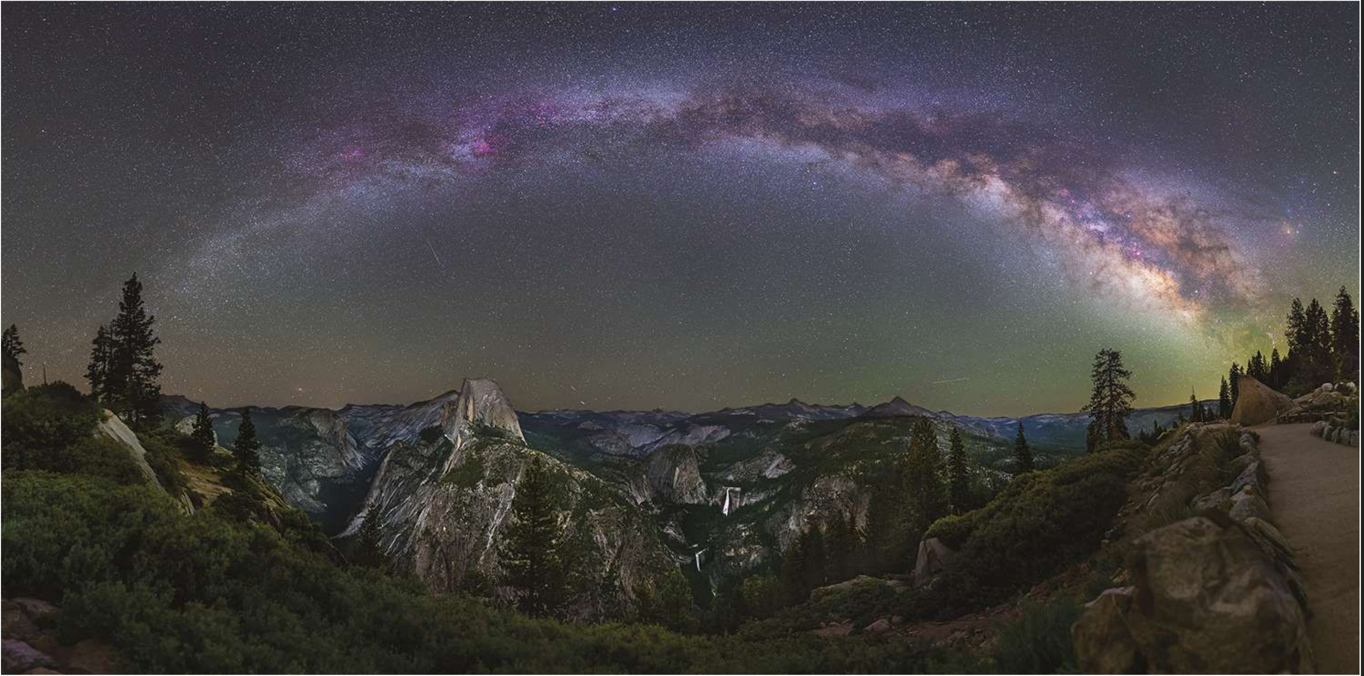
TREVOR NICHOLLS, CHELMSFORD, 4 DECEMBER 2015

Trevor says: "I had been trying to photograph this area well for a while using a one-shot-colour camera. Now I have a mono camera and narrowband filters I wanted to capture the target in more detail. I am pleased with how this one turned out: I managed to get the level of detail I was after and I feel the image presents a different view of a familiar object."

Equipment: QSI 6120 cooled CCD camera, Takahashi FSQ-106ED apo refractor, Paramount MX mount, Astrodon 5nm filters.

***BBC Sky at Night Magazine* says:** "There is so much going on in this photo: the dusty dark horsehead set against IC 434 in the background, consisting of green and yellow hues peppered with bright blue stars. A busy, visually arresting image."

About Trevor: "I have been interested in astronomy and photography for a long time, but it was not until 2011 that I got my first scope. I very quickly took up astrophotography and, a couple of scope upgrades later, settled on my current equipment a year ago. I had a roll-off roof observatory installed last summer and it is fully automated, allowing me to image through the night and make the most of the UK skies."

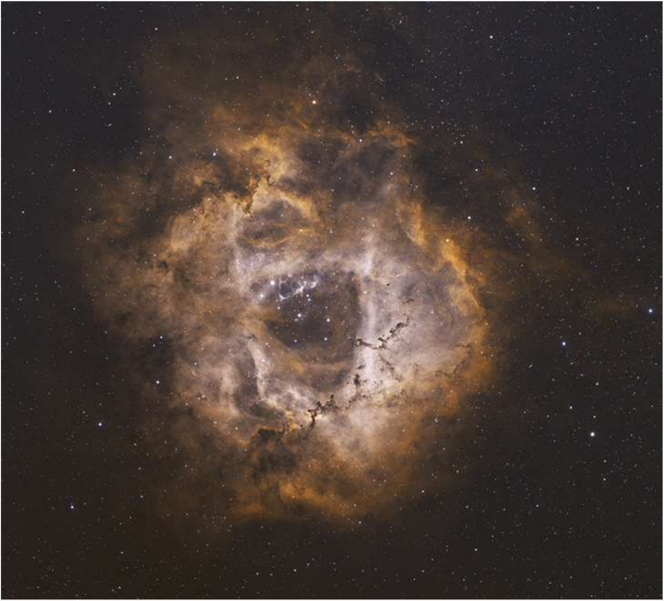


▲ The Milky Way over Yosemite National Park

DAVID LANE, CALIFORNIA, US, 6 DECEMBER 2015

David says: "This is one of the hardest images I have ever captured. At night you can't see the falls from Glacier Point but you can hear it: a distant roar to keep one company in the darkness. The altitude was great for visibility, although some of the greens and yellows are light pollution from the major cities in California's central valley."

Equipment: Canon EOS 6D DSLR camera, iOptron iPano mount.

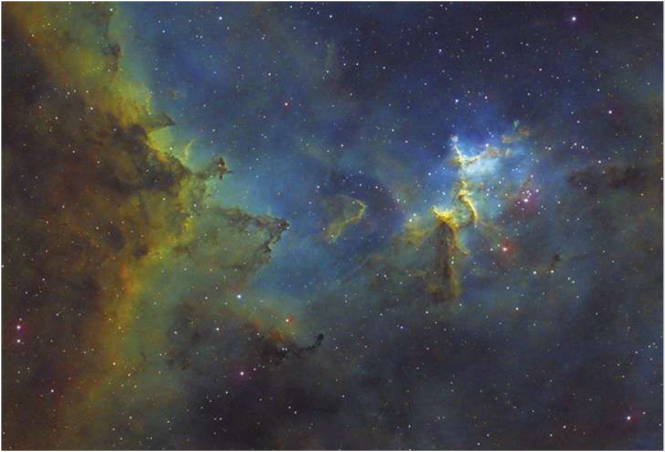


▲ The Rosette Nebula

CHRIS HEAPY, MACCLESFIELD, 31 DECEMBER 2015

Chris says: "The Rosette Nebula is a favourite winter object of mine but it is actually quite large and difficult to fit onto the sensor. I set out to capture a three-channel Hubble composition but poor weather put paid to that idea, so the image consists of just two channels, OIII and Ha composited as a bi-colour image."

Equipment: Moravian G4-16000 CCD camera, Tele Vue NP127is refractor, 10-Micron GM2000 HPS mount.

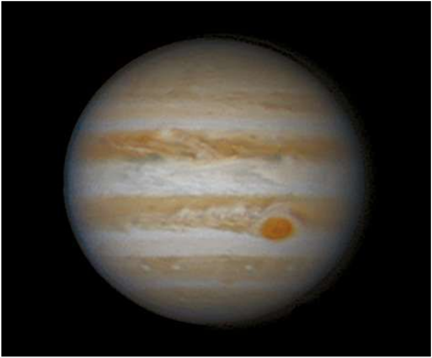


▲ Open cluster Melotte 15

PAUL FEARN, NORWICH, 9 DECEMBER 2015

Paul says: "The restricted field of view on my Atik 314L+ encourages me to look for smaller regions of larger deep-sky objects."

Equipment: Atik 314L+ mono cooled CCD camera, Sky-Watcher Equinox-80 ED apo refractor, Sky-Watcher HEQ5 Pro SynScan mount, Baader Ha & OIII filters, Astrodon SII filter.

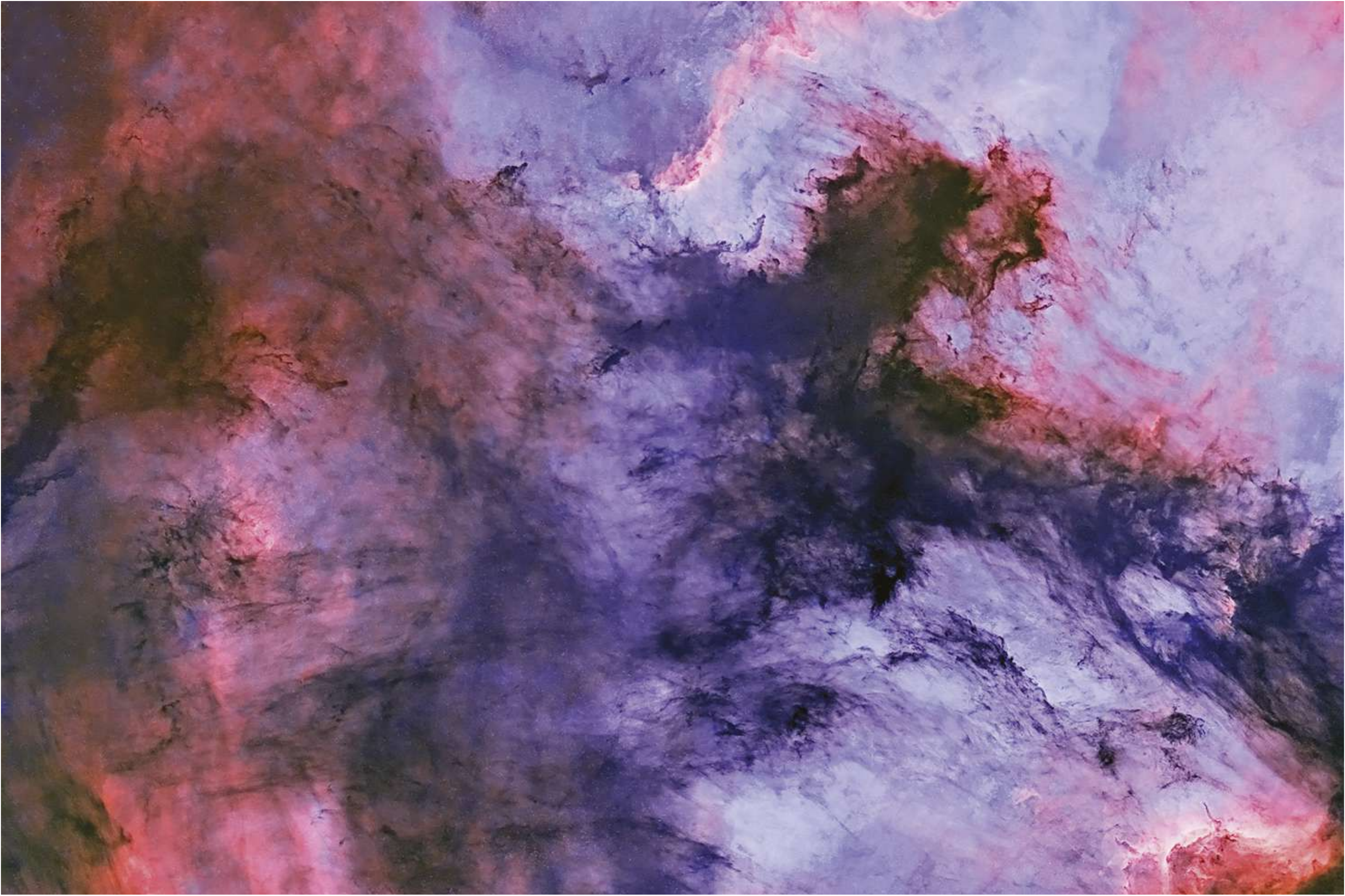


◀ Jupiter

PAUL WILLIAMSON, ABU DHABI, 28 DECEMBER 2015

Paul says: "I borrowed a friend's C11 to see first hand the difference the aperture makes, as I own a C8. I was so impressed that I have already upgraded."

Equipment: The Imaging Source DMK 21AUG618 USB 2.0 monochrome industrial camera, Celestron C11-A XLT (CGE) optical tube, Tele Vue 2.5x Powermate, Baader RGB filters.

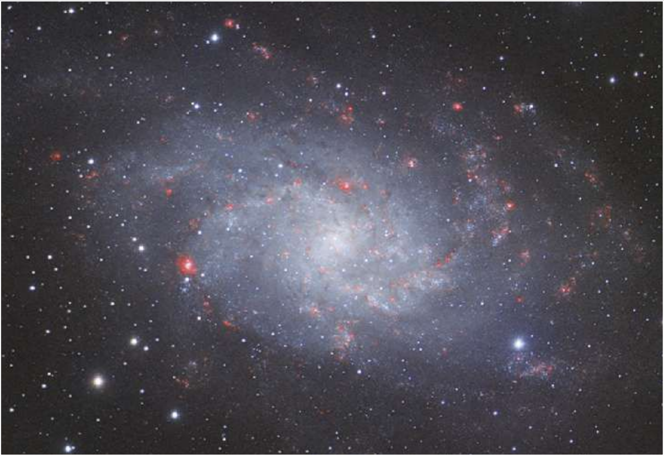


▲ The Pelican and North America Nebulae

ROB PRESTON, WORCESTERSHIRE, 16 JULY 2015

Rob says: "I wanted to experiment with starless images using JP Metsavainio's Photoshop method, and the Christmas break gave me two weeks to do so!"

Equipment: Atik 383L+ mono CCD camera, Sky-Watcher Explorer 130P-DS 5-inch Newtonian, Sky-Watcher NEQ6 Pro SynScan mount.



▲ Triangulum Galaxy

ROGER BROOKER, SEASALTER, KENT, 10 NOVEMBER 2015

Roger says: "Getting the Ha data blended in correctly proved tricky, but I like the way it has made the regions stand out more."

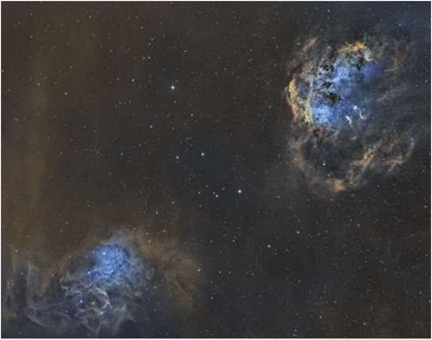
Equipment: Starlight Xpress Trius-SX695 monochrome CCD camera, William Optics 110 DDG triplet apo refractor, Baader filters.

▼ The Flaming Star Nebula

PAUL C SWIFT, VALENCIA, SPAIN, 24 DECEMBER 2015

Paul says: "This image is at the centre of my continuing study of the constellation of Auriga. Due to erratic weather conditions, data acquisition was spread over a month."

Equipment: Starlight Xpress SXVR-H18 camera, Vixen Optics VSD100F3.8 ultra-fast astrograph, Paramount MX mount.



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ALTAIR ASTRO We've joined forces with Altair Astro UK to offer the winner of next month's Hotshots an Altair Astro Premium City Light Suppression CCD Filter. This device filters light pollution from long exposure images and is designed for DSLR, CCD and CMOS cameras. www.altairastro.com • 01263 731505

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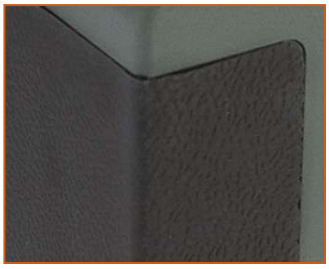

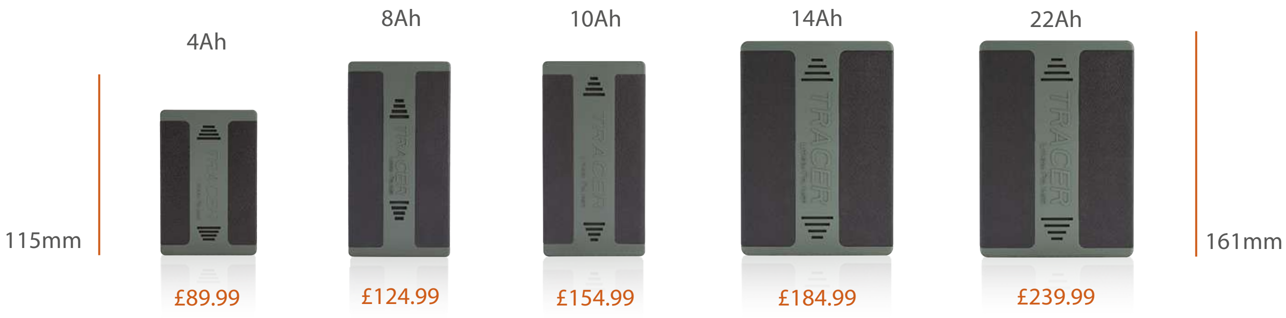

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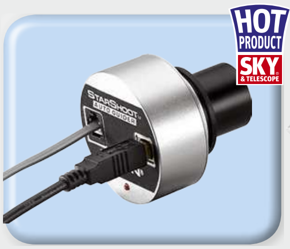

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JUPITER

THE DEFINITIVE OBSERVING GUIDE

Jupiter is high and bright – make the most of the views with our expert advice at the eyepiece, sketch pad and camera screen

This month Jupiter will be unmissable in the night sky, its creamy glow gracing an otherwise faint area of sky below the main constellation stars of Leo. On 8 March it comes to opposition and will be visible from early evening right through to daybreak. For us on planet Earth, with the Sun on one side of our orbital path and Jupiter facing it on the other, it means that we're in for the planet's highest and brightest presentation of the year. This is the time to make the most of observing the Solar System's largest planet and on the following pages, our experts give their advice on what to watch for this apparition and how best to observe, draw and image the dramatic planet and its moons.

THOMAS WINTERER/CCDGUIDE.COM

ABOUT THE WRITERS

JOHN ROGERS

John is director of the British Astronomical Association's Jupiter Section and a neuroscientist. He gives us an update on what's been happening so far this apparition on page 34.

PAUL ABEL

Sketching expert and visual observer Paul is an astrophysicist at the University of Leicester. He tells us how to make the best observations of the gas giant and gives tips on sketching on page 35.

STEPHEN TONKIN

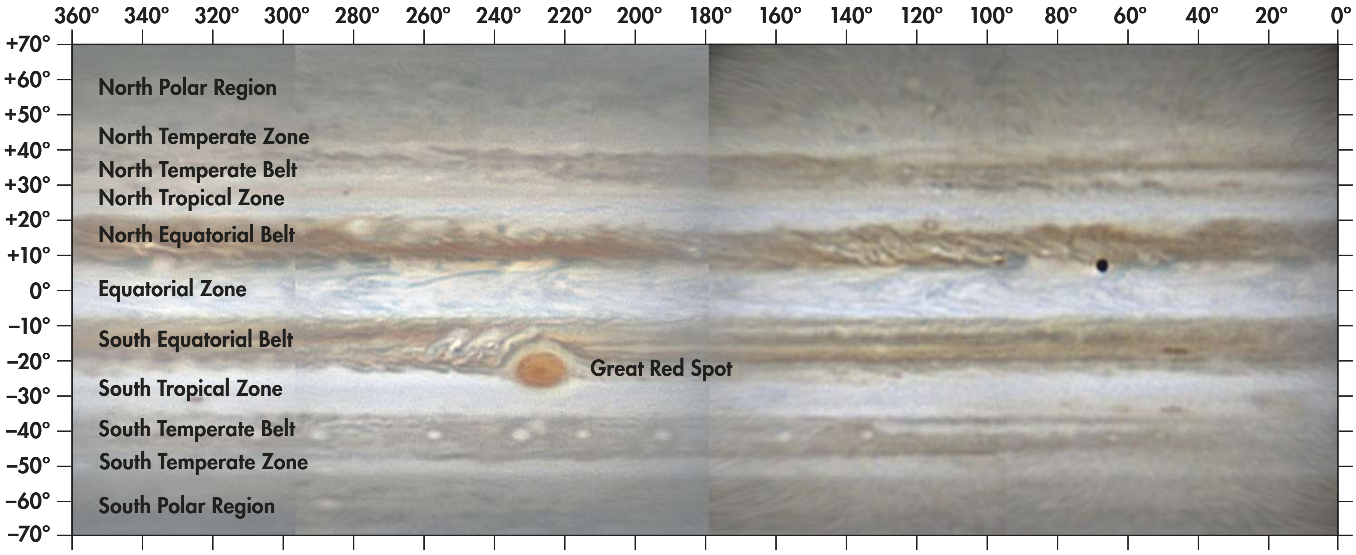
Binocular observer Stephen explains how to take a wider view this opposition – by watching the ballet of the Galilean moons and Jupiter's apparent motion on the sky. Read more on page 36.

DAMIAN PEACH

Planetary imager Damian is well-known for his pin-sharp images of Jupiter. Here he offers his advice on how to take the best images possible this opposition on pages 36 and 37.

Jupiter's current state

John Rogers recounts what has been happening on Jupiter so far in the 2015-16 apparition, from the Great Red Spot to its less-famous features

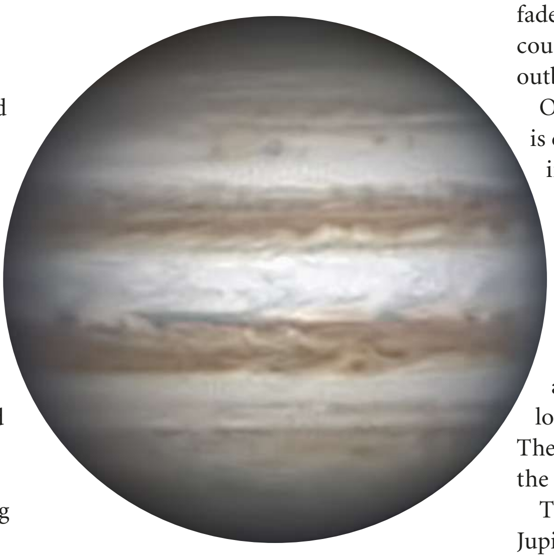


▲ Jupiter's myriad zones and belts, with distance from the equator; rapidly changing features can appear across the planet's surface

JUPITER'S TURBULENT ATMOSPHERE is always changing, and there are always interesting phenomena to watch. The best-known feature, the giant anticyclone known as the Great Red Spot, is unusually red at present – as red as it has ever been.

It is also smaller than ever before, so that cloud features circulating within it complete a circuit in only 3.7 days, as recorded by amateur imagers – half the period recorded during the Voyager missions in 1979. Moreover, the Hubble Space Telescope reveals even faster winds within the Great Red Spot, blowing at 150m/s, equivalent to a circulation period of only 3.2 days. Scientists speculate that the shrinkage has reduced the disruptive effect of the jet streams which border the Great Red Spot, and has thus allowed the red colour to accumulate more than usual. It has been shrinking for a century or more, and the recent changes suggest that it may not last for another century.

The Great Red Spot is partly embedded in the South Equatorial Belt, which is a typical dark belt at present. Its most conspicuous features are rapidly changing bright spots just west of the Great Red Spot, which have been shown by spacecraft to be giant thunderstorms. On the other side of the equator, the North Equatorial Belt is undergoing a major change involving progressive broadening to the north, which happens every three to five years. In autumn 2015, a sector was already expanded, and the broadening is gradually spreading eastwards. There is also vigorous disturbance within some sectors of the belt. Observers may notice long bright streaks and white spots: convective storms similar to those west of the Great Red Spot. By the end of 2016, we expect a series of oval circulations to be developing in the expanded northern half of the belt.



▲ Jupiter imaged on 9 January, when the Great Red Spot was out of view; the belts may also hold smaller storms in the form of white spots

The next dark belt to the north is normally the North Temperate Belt, but this too undergoes large-scale cycles, of which the most recent was initiated with a hugely energetic outburst in 2012. This has now evolved to darken a long sector of the usually white zone to the north. In contrast, the southern half of the belt has faded to a pale fawn colour. These changes could be leading up to a new energetic outburst in early 2017 or thereabouts.

On 5 July 2016, NASA's Juno spacecraft is due to enter orbit around Jupiter and in the autumn it will start its scientific work. Although this will mostly not involve imaging the atmosphere, Juno does carry a camera which will take some images on each orbit, and NASA is inviting the public to participate by imaging the planet with amateur telescopes and by proposing locations to be imaged (see page 37). Therefore, observers will be monitoring the planet with special assiduity in 2016.

The British Astronomical Association's Jupiter section (**www.britastro.org/jupiter**) also has a very active programme and I greatly encourage observers to submit their images for further study.

ANNOTATED JUPITER MAP MADE BY MARCO VEDOVATO FROM IMAGES BY T HORIUCHI AND C GO, PETE LAWRENCE, CHART BY PETE LAWRENCE, PAUL ABEL X 2

Telescopic Jupiter

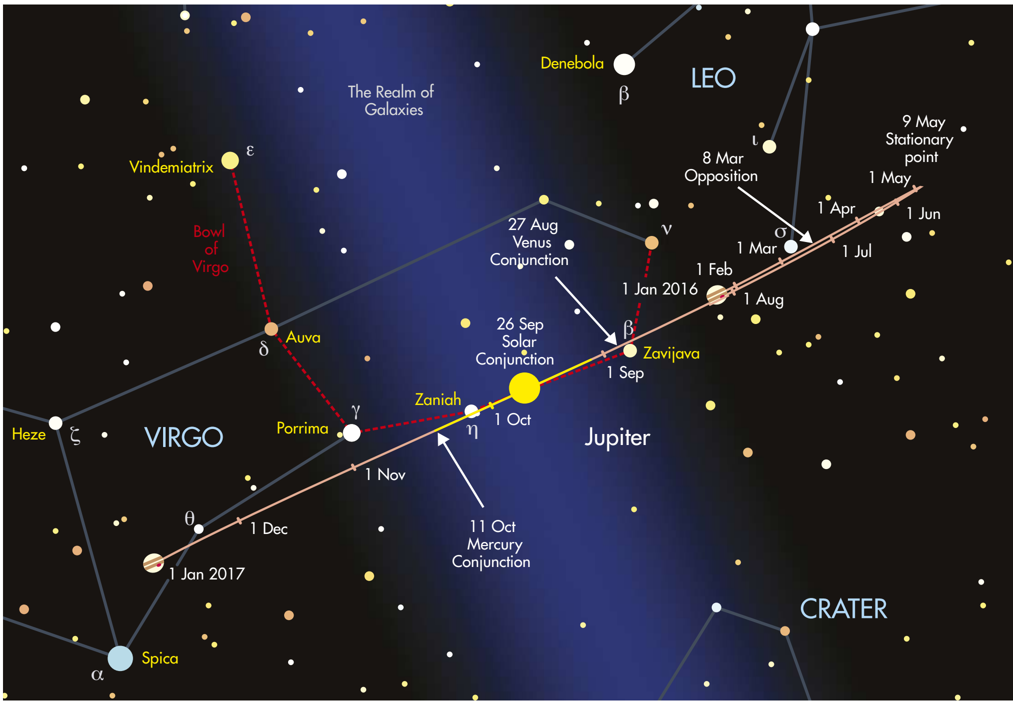
Making a quick drawing to complement your visual observations not only creates a lasting record but also helps to concentrate your eyes, says **Paul Abel**

THE BRIGHT BEACON of Jupiter returns to our evening skies, coming to opposition early in March. It dominates the southeastern skies after sunset, residing in the constellation of Leo until early August.

Jupiter's vast size and colourful cloud tops make it a great target for amateurs. In a small telescope, Jupiter appears as an appreciably flattened disc, the two main equatorial belts are visible, and on good nights, the belt edges are somewhat mottled and irregular. When prominent, the Great Red Spot can be viewed in a 4-inch telescope.

Larger telescopes reveal a vast amount of detail: additional thin belts and brighter zones, spots and storms in the south and bluish festoons along the equator. Visually, Jupiter doesn't tolerate high powers, so it's best to stick to magnifications between 190x and 280x. Filters are a great help: a light blue filter will enhance details inside the main belts and darken the Great Red Spot, while a yellow one will help sharpen the contrast between the belts and zones.

Jupiter has a dynamic atmosphere: some storms have raged in the upper atmosphere for hundreds of years, while others have lasted only a few decades.



▲ **Jupiter is moving through Leo, and will be near the Lion's rear paw when it comes to opposition**

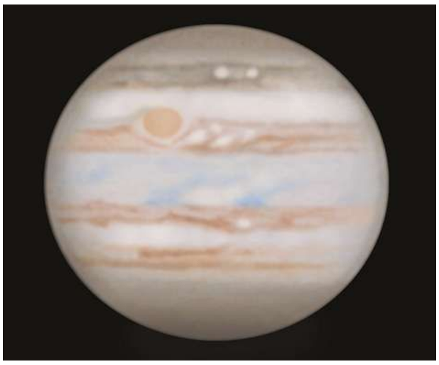
You can keep track of these changes in Jupiter's weather by making a drawing. You'll need a clipboard, a red light, a selection of pencils (B to 4B) and an eraser. It's best to keep your drawings in a sturdy log book so you have them in a safe place.

A template that correctly represents Jupiter's squashed appearance is essential – if you use a circle your sketches will be badly skewed. You'll find one of these in this month's Bonus Content (**www.skyatnightmagazine.com/BonusContent**). Don't make a drawing straight away, but spend 10 minutes observing Jupiter, carefully noting which features are present before you begin.

The race is on

A day on Jupiter is less than 10 hours long, so you only get 12 minutes to draw the planet before its rotation moves any visible features. Spend the first six minutes sketching in the two main equatorial belts, any other fainter belts and the Great Red Spot if present. Next add any obvious storms and spots, before spending the last few minutes putting in the finer details visible inside the belts (bright gaps and darker sections for example). Remember to add the date, time (in UT) and telescope details to your sketch. You might want to make a couple of drawings in a session.

We'll have Jupiter in our skies for some time. Start recording the planet now and you'll soon collect a large number of drawings that chart the changes in the planet's restless atmosphere. ▸



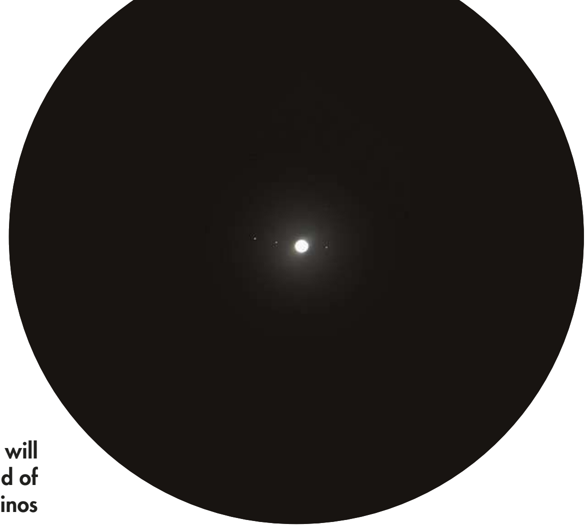
▲ **Paul uses an 8-inch Newtonian reflector (left) for his sketches of Jupiter; the finished sketch (right) was completed on 21 January at 250x magnification**

Motion and moons

Watching Jupiter with the naked eye or binoculars reveals rewarding sights, says **Stephen Tonkin**

TO THE NAKED eye, this opposition of Jupiter is very bright and obvious, even in an urban sky. Blazing at mag. –2.6, only the Moon will outshine it in the night sky. Somewhat more subtle is the changing rate of its apparent motion against the background stars. If you plot its position for several weeks either side of opposition as it moves westwards (retrograde) past mag. +4.1 Sigma (σ) Leonis, you should notice that it moves slightly more from night to night when it is near opposition.

In binoculars, you may not notice any difference in the appearance of the planet itself: it remains a small bright disc but, just as the disc appears larger to telescope users, the greatest separations of its moons from the planet (elongations) also appear larger. If you have never seen Jupiter's Galilean moons before, use binoculars or a telescope to have a go near opposition. The chart on page 53 shows you when they are at greatest elongation.



► All four Galilean moons will comfortably fit into the field of view of a standard pair of binos

Imaging Jupiter

Renowned planetary imager **Damian Peach** gives his advice on the equipment, techniques and processing steps to take great images of Jupiter this opposition

JUPITER'S PRIME POSITION in March presents an ideal opportunity to try your hand at photographing it. The Solar System's largest planet comes to opposition on 8 March and will be visible throughout the night, shining brilliantly at mag. –2.6.

Modern high-speed video cameras are providing us with views of Jupiter in such extraordinary detail that the finest amateur imagery taken today approaches that taken by the world's largest mountaintop observatories in previous decades. In recent years these amateur images have allowed the general meteorology of the Jovian atmosphere to be observed in unprecedented detail. Even small amateur telescopes equipped with a webcam can produce valuable imagery.

The most popular cameras in use today are the various types of high-speed video CCD cameras such as those from ZWO. Lower cost alternatives are available such as the Celestron NexImage Solar System Imager, or you might be able to find a secondhand, adapted Philips Toucam or SPC900 webcam on Ebay or Amazon Marketplace.

▲ Older webcams such as the SPC900 (left) and Philips Toucam (right) still offer great imaging potential, but these days they're only available secondhand

◄ In lieu of a webcam, a high frame rate camera is a fine alternative

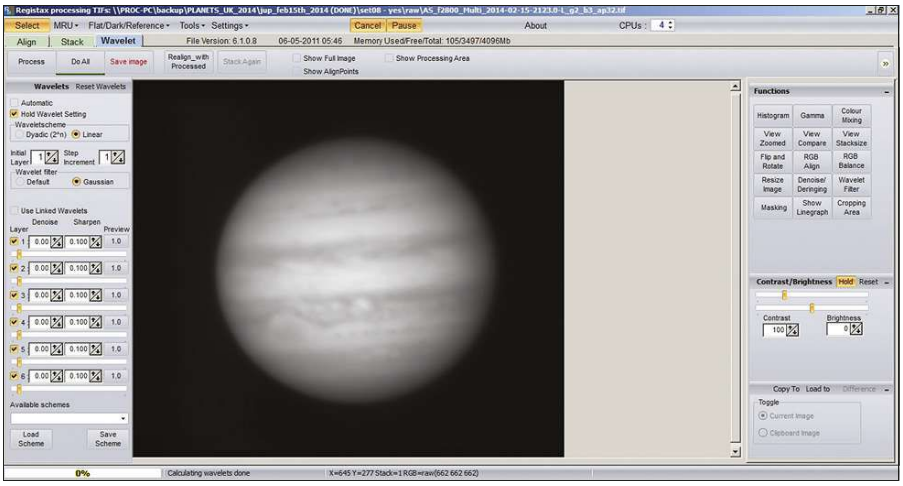
Using such cameras it's possible to take detailed images even with modest-sized telescopes. For those starting out, a colour camera is by far the easiest way to get nice colour images of the planet, though a monochrome camera with different filters can bring out different details on the planet.

Preparing your setup

Imaging Jupiter with any telescope is a fairly straightforward process. The telescope's focal length needs to be increased to give a good sized image on the camera chip; a focal ratio of around f/20 to f/30 is a good point to aim for. Due to Jupiter's rapid rotation you are limited to a maximum capture time of only a couple of minutes within which to obtain as many frames as you can.

Collimation and focusing are very important for any telescope to perform

PETE LAWRENCE, WWW.SECRETSTUDIO.NET, DAMIAN PEACH X 5



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☐ Automatic
☑ Hold Wavelet Setting
Waveletscheme: ○ Dyadic (2^n) ● Linear
Initial Layer 1 Step Increment 1
Wavelet filter: ○ Default ● Gaussian
☐ Use Linked Wavelets

Layer	Denoise	Sharpen	Preview
☑ 1	0.00	0.100	1.0
☑ 2	0.00	0.100	1.0
☑ 3	0.00	0.100	1.0
☑ 4	0.00	0.100	1.0
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Contrast 100 Brightness 0

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▲ Freeware program RegiStax is a great all round processing package, and a great place to start with processing your video image sequences into a higher quality still image

▲ Damian's setup: a 14-inch Schmidt-Cassegrain equipped with motorised focuser, filter wheel and atmospheric dispersion corrector

◂ A motorised focuser (left) and atmospheric dispersion corrector (right) – two very worthwhile accessories for aspiring planetary imagers

well, so be sure to take some time over these steps. A motorised focuser would be a great addition to your telescope if you don't already have one. Another very useful accessory to invest in is an atmospheric dispersion corrector. This device corrects the smearing of light due to the low altitude of an object in the sky. This will be very useful especially for larger telescopes operating with colour cameras.

Monochrome cameras are more versatile as they allow you to focus on specific wavelengths with coloured filters. Infrared filters are especially useful in helping to produce images in poorer seeing conditions or when the planet is lower in the sky as long wavelengths are less affected by atmospheric turbulence. More specialised filters such as those that let through light from the methane absorption band at 889nm can also produce especially interesting images.

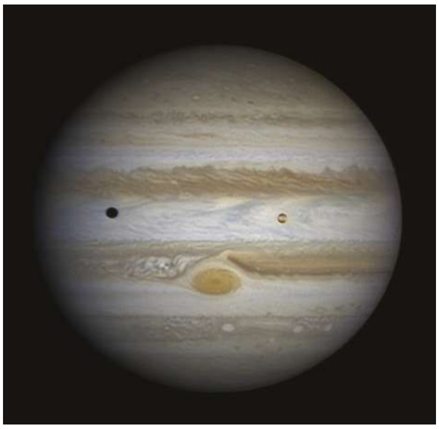
Free software is widely available for both controlling the camera and processing the imagery obtained. FireCapture (**www.firecapture.de**) is the most popular camera control software and is freely available for download. The freeware programs RegiStax (**www.astronomie.be/registax**) and Autostakkert! (**www.autostakkert.com**) are the most popular available for processing the captured images. They offer a range of processing functions, from image alignment to wavelet sharpening. Autostakkert! is the better program for image alignment and stacking, whereas RegiStax excels as a post-processing package for sharpening your images. When processing your data, be sure to stack a good number of frames to help reduce noise – you'll need several hundred at least. Also be careful not to sharpen the image too aggressively as this can lead to false detail being created.

Send your pics to NASA

With the Juno spacecraft due to arrive at Jupiter in July, now has never been a better time to start taking regular images of the planet. NASA is calling on amateur astronomers to submit their images to help decide on imaging targets for one of the probe's instruments, the JunoCam. Full details on how to submit images can be found on NASA's website (**www.nasa.gov/feature/jpl/to-jupiter-with-junocam**).

As well as the British Astronomical Association's Jupiter Section, there are also several active groups of professionals and amateur astronomers on social media. The Astronomy Planetary Imaging Facebook group contains many experienced observers and scientists. Other online groups include the Association of Lunar and Planetary Observers (**http://alpo-astronomy.org**), and the Association of Lunar & Planetary Observers Japan (**http://alpo-j.asahikawa-med.ac.jp/indexE.htm**). Ⓢ

▲ This image was taken in 2003 using a Philips Toucam attached to an 11-inch telescope; proof that even webcams can produce detailed imagery



▲ Another perspective of Jupiter, captured with Io and its shadow transiting the planet

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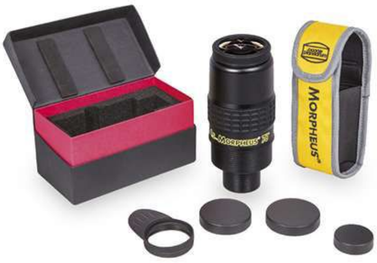

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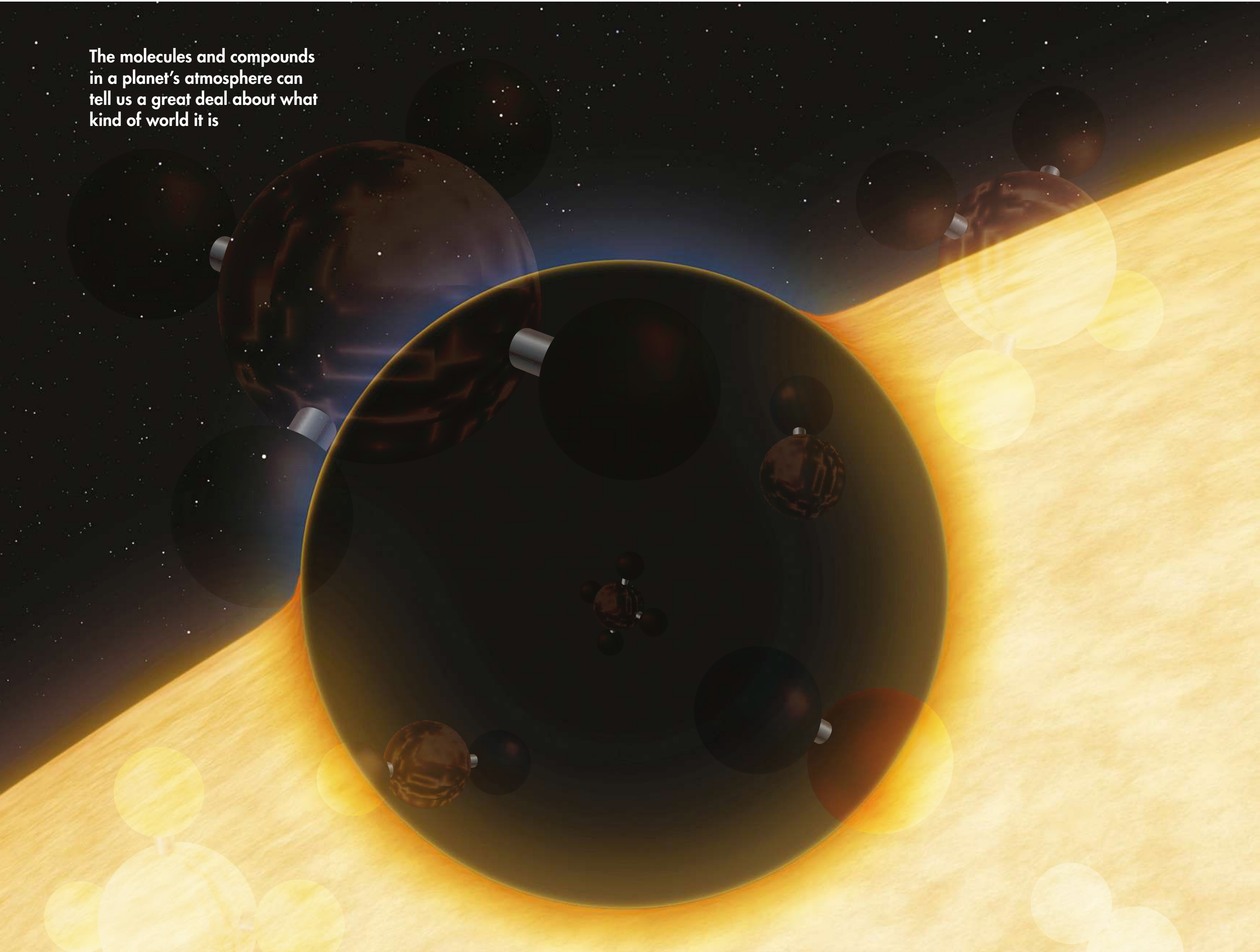


The molecules and compounds in a planet's atmosphere can tell us a great deal about what kind of world it is

CLOUDY WITH A CHANCE OF METHANE

One day we may be able to predict the weather on distant worlds, as **Elizabeth Pearson** explains

NASA/JPL-CALTECH, ISTOCK

▲ **Hot Jupiters bear close similarity to their Jovian namesake – save for the fact they orbit so close to their parent stars**

Our Galaxy is littered with worlds, from gas giants that skim past their stars to super-Earths only a few times more massive than our planet. In recent years, the field of exoplanet research has boomed, detecting thousands of new planet candidates. But finding them isn't enough anymore. Now we need to know what these worlds might be like.

Getting up close and personal as we have done with our companions in the Solar System isn't an option. These exoplanets are so far away that we can't even begin to consider sending probes to take pictures and create maps. Yet it is still possible to get to know them better, not by looking at the planet itself, but at the star it orbits. By examining the light from its host star, we can learn a great deal about the composition of an exoplanet's atmosphere.

"Some of the starlight is filtered through the planet's atmosphere and when it hits the molecules in the atmosphere it makes them swing and rotate," says Lisa Kaltenegger from the Carl Sagan Institute at Cornell University. Each element and molecule has a specific energy of light that causes it to move and it absorbs only this specific energy of light when it's struck. "That light is missing when the light gets to the telescope – it's used up. And this is how you can tell exactly what chemicals are in the atmosphere of a planet."

This technique is called spectroscopy, and by using it to look at the light from the host star it is possible to find 'spectral features', specific energies that are missing from the stellar light. The unique pattern of features spells out what elements are found inside the atmosphere. But the observations are extremely difficult to make and there are limits to what can be determined.

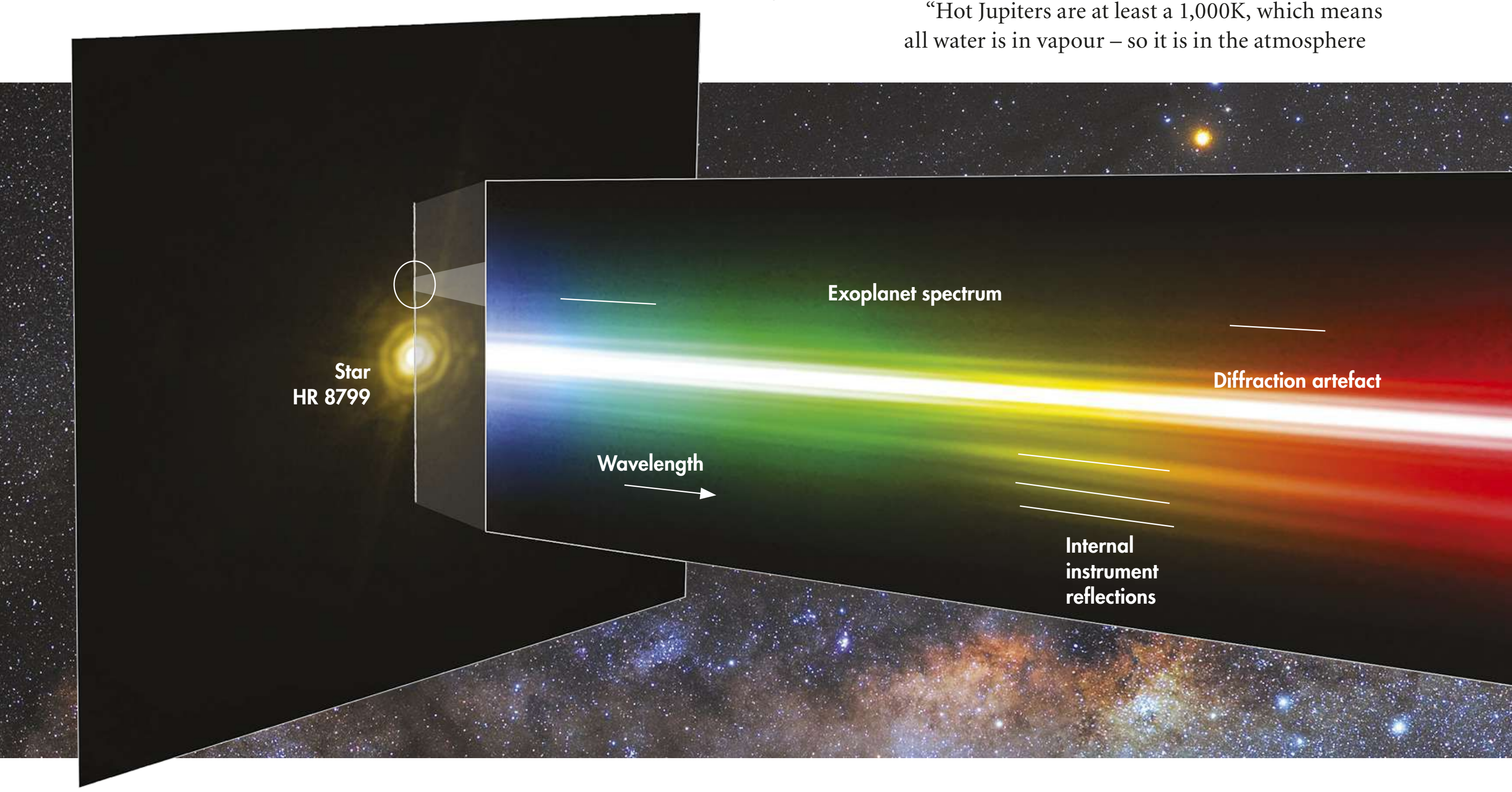
"A lot of the science is driven by the observations we can currently make. The Hubble Space Telescope's Wide Field Camera 3 can detect strong features due to water and methane, but can only make good measurements for hot Jupiters," says Nikku Madhusudhan, an astrophysicist from the University of Cambridge.

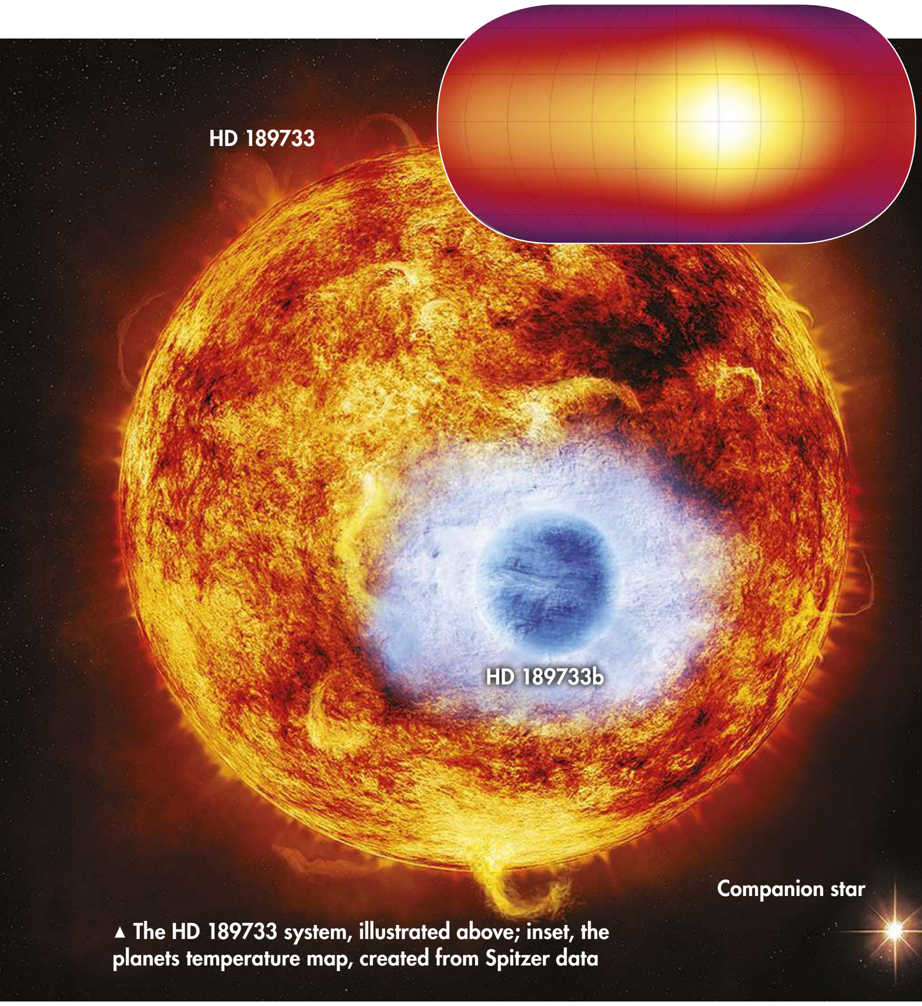
Giant roasters

Hot Jupiters are gas giants that are incredibly close into their stars, earning them the nickname 'roaster planets'. Their tight orbits cause their atmospheres to become superheated and expand.

"Hot Jupiters are at least a 1,000K, which means all water is in vapour – so it is in the atmosphere

▼ **Picking the planet out of the starlight is tricky; the spectra detected often hold misleading artefacts**





▲ The HD 189733 system, illustrated above; inset, the planets temperature map, created from Spitzer data

THE WORLD WITH 8,700km/h winds

The exoplanet HD 189733b, located 63 lightyears away in Vulpecula, is not what could be classed as a hospitable world. This hot Jupiter loops around its star 30 times closer than the Earth does to the Sun, completing an orbit every 2.2 days.

Like many of its close-orbiting fellows, HD 189733b is tidally locked. While one side reaches enormous temperatures, the other freezes. Over the course of the planet's orbit the Spitzer Space Telescope managed to track changes in the planet's infrared emission, creating a thermal map of the planet showing this split personality.

The huge dichotomy of temperature, combined with a thick atmosphere, creates such a stark air pressure difference between the two sides that it results in winds that blow as fast as 8,700km/h.

"One hemisphere will have winds blowing in one direction towards you, whereas the other hemisphere will have winds blowing away," says Laura Kreidberg of the University of Chicago. You can compare the spectral features of the two and measure the Doppler shift and use that to constrain how fast the wind is blowing.

At 8,700km/h, the winds gust at more than four times the speed of fastest measured in our Solar System, which are found on Neptune. There, bands of storms whip and whirl at a comparatively tame 2,100km/h.

and you can see it in spectra," says Madhusudhan. "We don't know the water abundance of Jupiter within our own Solar System. For the first time there is a quantity that we can measure better in an exoplanet than we can in our own Solar System."

Luckily water is key for planet formation, and so understanding it is critical to understanding how these worlds came to be. It is also vital for finding habitable worlds, a task which exoplanet searches have always been inextricably linked with.

But here comes the problem. Currently, we can't look for water, or any other atmospheric molecule, on an Earth-like planet. On a hot Jupiter the change in brightness betraying the presence of water is 0.01 per cent, which is difficult enough. For an Earth-like planet the change is 10 times smaller, far beyond the capabilities of current equipment. But this may not remain the case for long.

> **"We are creating a database of these spectral fingerprints of other worlds, other Earths"**

"When the James Webb Space Telescope (JWST) goes up it will catch enough light to look at the atmospheres of planets like Earth. It's going to take a lot of time but it will be technologically possible to do it," says Kaltenegger.

To make sure they are ready for the results when they come, Kaltenegger has already begun predicting what it is that the JWST would see if it looked at a world like our own.

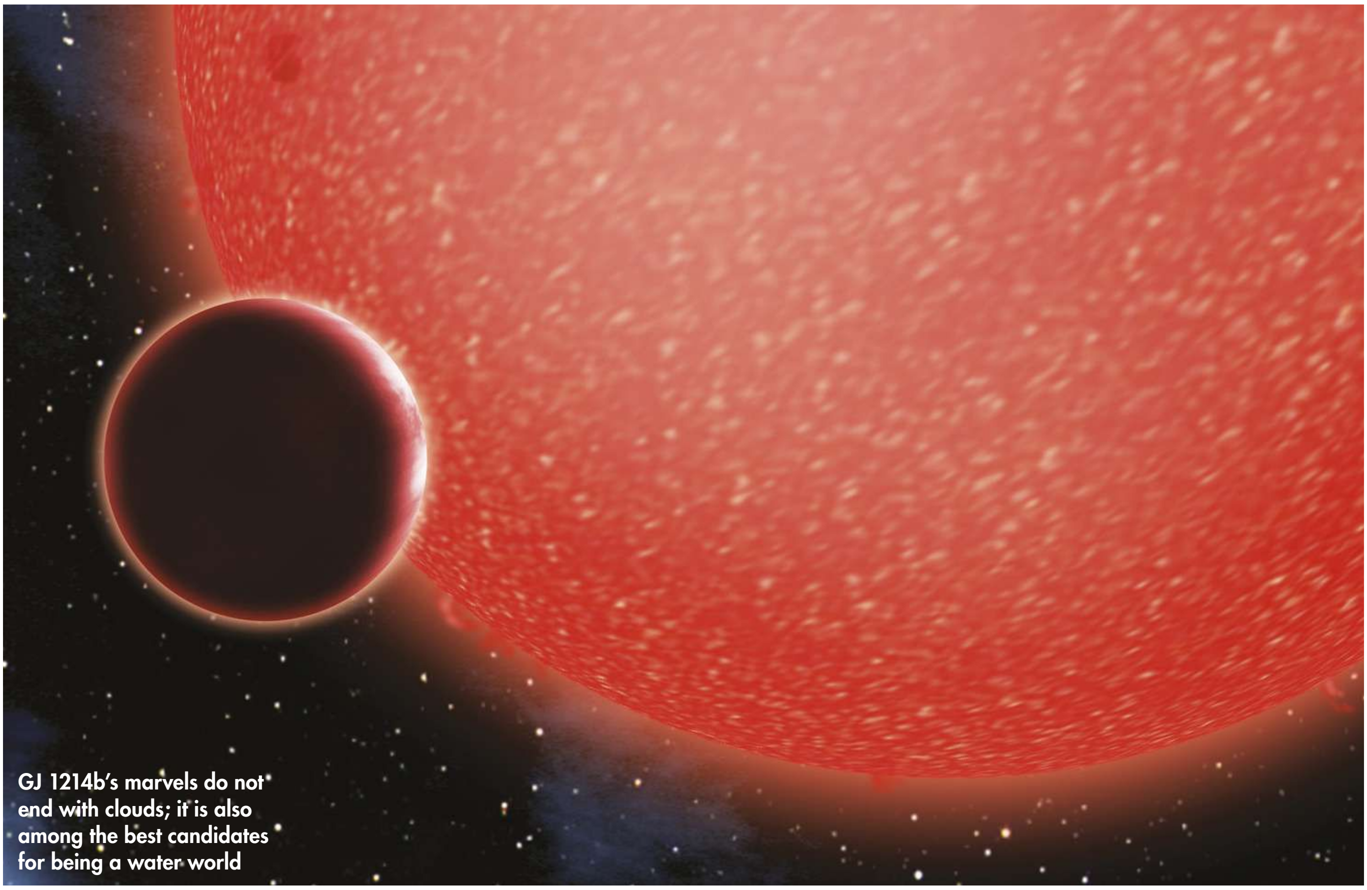
"We know what Earth looks like now, but what if it was younger? Earth and its atmosphere looked significantly different when it was young. If you see another Earth-like world, chances are it's not going to be at exactly the same age. We are creating a database of these spectral fingerprints of other worlds, other Earths."

▲ Discovering a true Earth analogue is the grail for exoplanetary researchers

A glimpse of things to come?

This database will help scientists select the most interesting targets as they hunt for Earth-like ▸

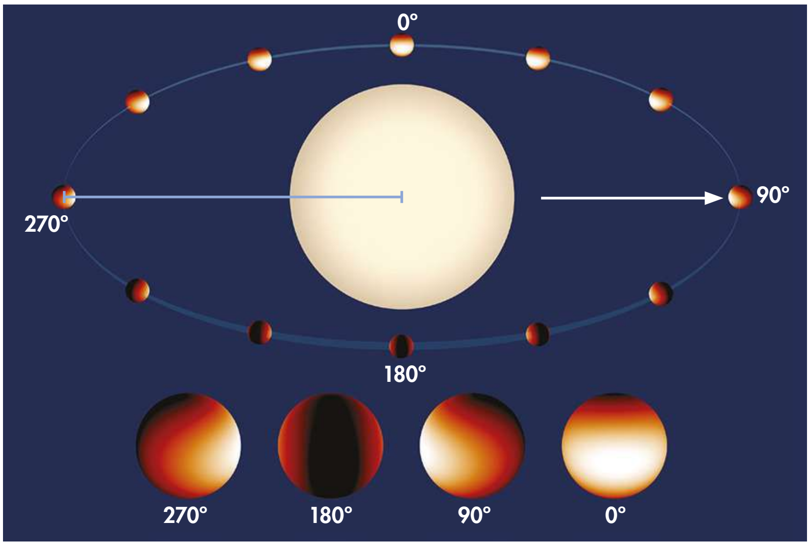
NASA/AMES/JPL-CALTECH X 2, ESO/M. JANSON, NASA/CXC/M.WEISS, NASA/JPL-CALTECH/HARVARD-SMITHSONIAN CFA



GJ 1214b's marvels do not end with clouds; it is also among the best candidates for being a water world

▸ worlds. But it's not just young Earths that we might find. Perhaps there are Earth-like planets much further down their evolutionary track out there.

"What if all the Earths that you see that are older have a lot of sulphur in their atmosphere?," says Kaltenegger. "That doesn't mean it is going to happen to our planet, but it means it would be very intelligent of us to use technology that can cycle sulphur out of the air. It's a potential glimpse into our future."



▲ **Wasp-43b's year only lasts 19 hours, allowing researchers to map changes in temperature**

Beyond detection

Already, though, we are beginning to take one step beyond detecting the simple composition of what makes up an exo-world's atmosphere to look into its climate and weather. The closest to Earth of those studied is GJ 1214b, a super-Earth 42 lightyears away in the constellation of Ophiuchus, orbiting the star Gliese 1214.

"On that planet we discovered clouds," says Laura Kreidberg of the University of Chicago. The discovery came not by looking for what was there, but what was not.

"We did not see any spectral features from things like water, ammonia, carbon dioxide or methane, and what we were able to work out from that was that there must be something in the atmosphere that is blocking the transmission of light," says Kreidberg.

It's even hoped that one day we'll be able to record the weather on another planet, watching how the climate changes throughout its year. Already this is being done on hot Jupiters, though their 'years' only last a few Earth days or even hours. If the years were more like that of Earth's then this would mean taking an already difficult measurement and spreading it out over a much longer period.

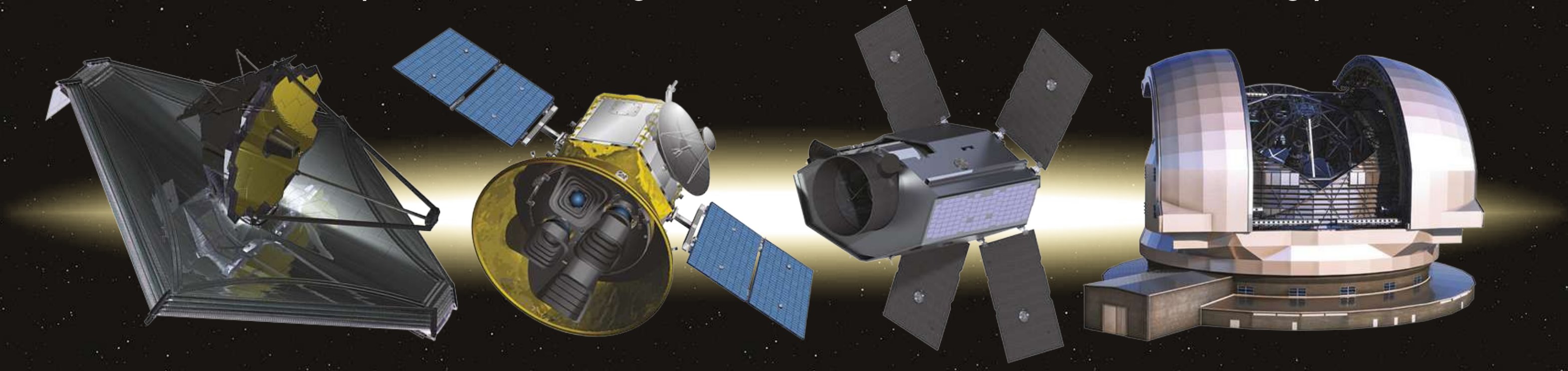
"It's hard to trust yourself that you really understand your instrument well enough to make that measurement, to distinguish between the instrument varying and the actual planet," says

"It's hoped that one day we'll be able to record the weather on another planet"

NASA ESA AND D. AGUILAR (HARVARD-SMITHSONIAN CENTER FOR ASTROPHYSICS), NASA/ESA AND Z. LEVAY (STSCI), NORTHROP GRUMMAN, MIT, TWINKLE/SSTL, ESO/L. CALÇADA, NASA/TIM PYLE

THE NEXT EXOPLANET HUNTERS

These are the scopes that will change the face of exoplanet research in coming years



JWST

Launch: October 2018

The JWST will use its 18m mirror to create enormously detailed infrared images. This huge light-gathering power will allow atmospheric spectroscopy for planets similar to Earth. Not only will it will be possible to image smaller planets, but it will also allow us to detect a wider range of compounds and molecules.

TESS

Launch: August 2017

TESS, or the Transiting Exoplanet Survey Satellite, will look for exoplanets around 200,000 of the brightest stars, searching for tell-tale temporary drops in brightness. Though it will not be able to characterise atmospheres itself, it will be able to find super-Earths around bright stars – worlds destined for follow-up study.

TWINKLE

Launch: 2018

Being designed and built in the UK, the Twinkle satellite is a low-cost mission that will analyse starlight in the visible and near-infrared wavelengths for organic molecules and the precursors to amino acids. It will also attempt to track changes over time and create weather maps of the exoplanets.

E-ELT

First light: 2024

Though based on Earth, the European Extremely Large Telescope's 39m mirror will be more than up to the task of detecting metals, water, oxygen and other molecules in exoplanet atmospheres. It will also be useful in investigating protoplanetary discs around young stars, from which planets may be born.

Kreidberg. "So I tend to be sceptical of those measurements."

It's likely that we'll be getting to know these distant worlds on a much more individual basis, but just like the Earth is not alone in our Solar System, these planets don't exist in isolation.

"I'm very intrigued by some of the Kepler multi-planet systems," says Kreidberg. "Having a bunch of planets in one system, some of which are rocky, is very reminiscent of our own Solar System. It's very exciting."

As we have found in our own planetary exploration, our neighbours, from Mercury to Pluto, are all vastly different. Is the same true for every other planetary neighbourhood?

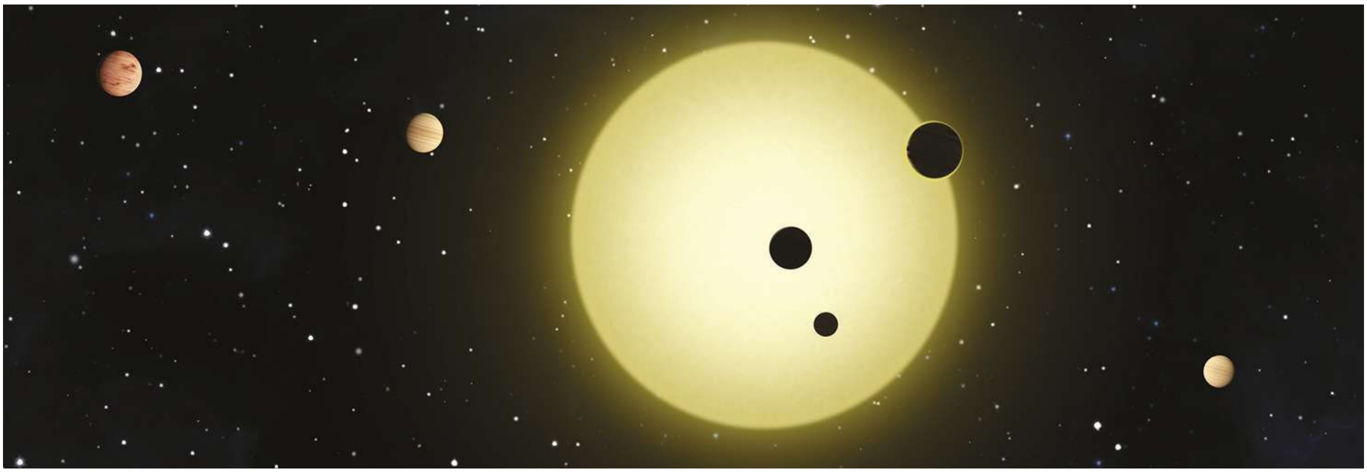
Looking at planets within the context of their own planetary systems is important not only for understanding how the worlds work with their neighbours but also how they fit into the wider picture, and that is what is at the heart of exoplanet research.

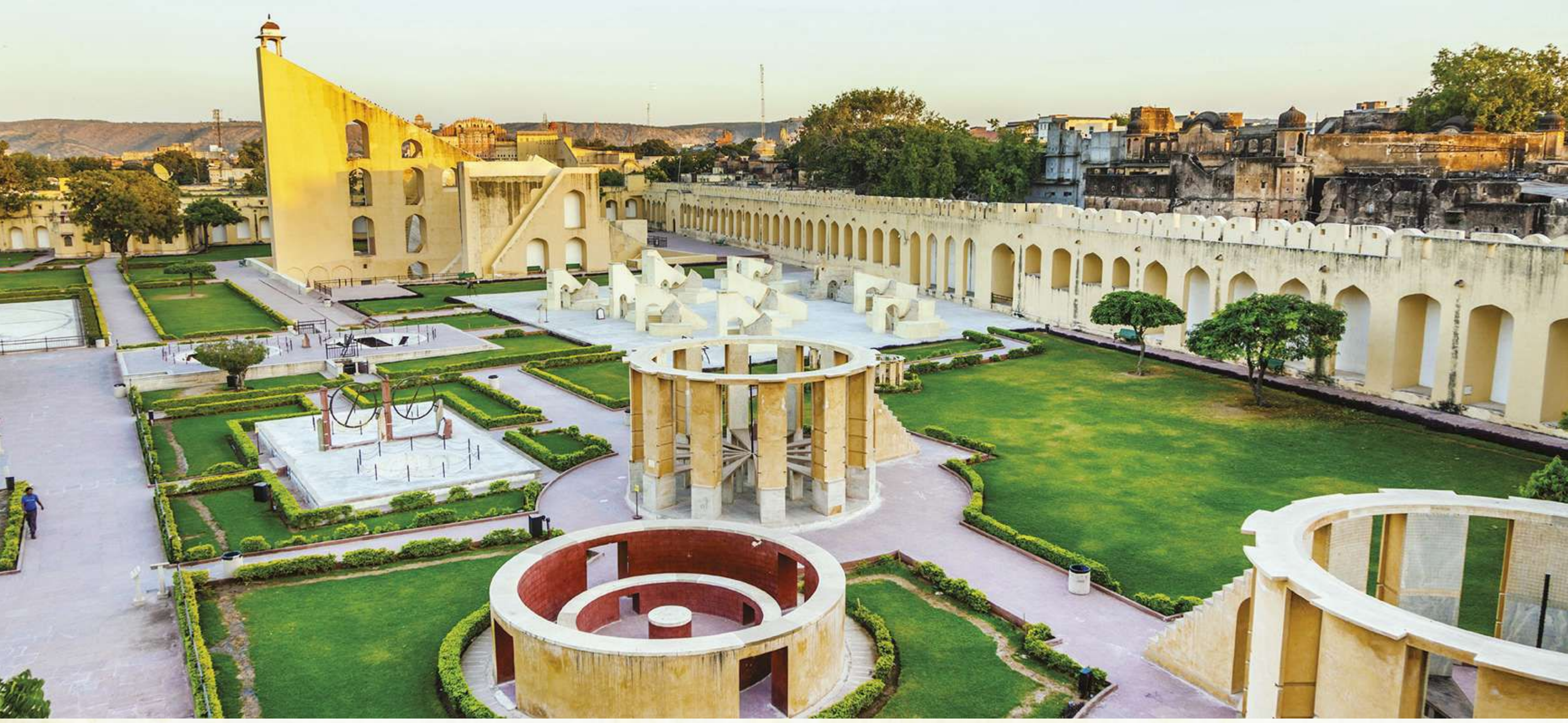
"I think it's very important to put our own world in context of the Universe that we live in," says Kreidberg. "There's great value in the self reflection that comes from looking at worlds orbiting other stars." Ⓢ

ABOUT THE WRITER

Dr Elizabeth Pearson is *BBC Sky at Night Magazine*'s news editor. She gained her PhD in extragalactic astronomy at Cardiff University.

▼ Kepler 11 is multi-world system' quite unlike ours, with six planets all larger than Earth but no bigger than Neptune



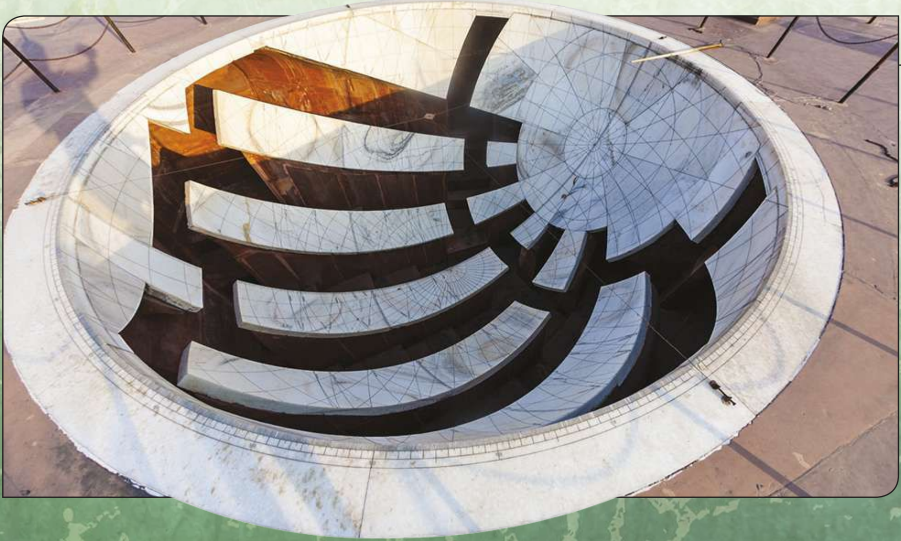


The Maharaja's MASTERPIECE

Khursheed Dinshaw reveals the secrets of the enormous stone observatories of northern India

Though it looks like a sculpture garden, what you see here is a colossal, 18th-Century astronomical observatory: the Jantar Mantar in Jaipur. It is one of five observatories in India to bear the name – the term is not a title, but Sanskrit for 'calculation instrument'. All were built by Maharaja Sawai Jai Singh II.

After finding that Muslim and Hindu calendars did not include accurate positions of the planets, he ordered a string of observatories to be built, with instruments 10 to 100 times larger than any that had gone before. This one was completed in 1738, with 19 majestic instruments built from lime plaster, marble, stone and bronze, some of which we explore here. It is a place of scientific significance and great beauty – and as of 2010, a UNESCO World Heritage Site.



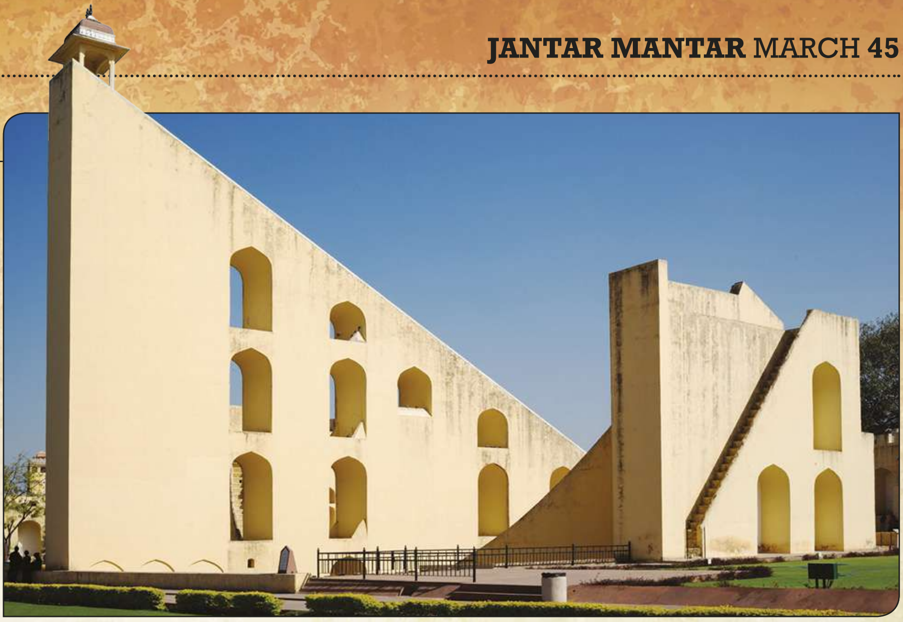
ISTOCK X 5, KHURSHEED DINSHAW X 2

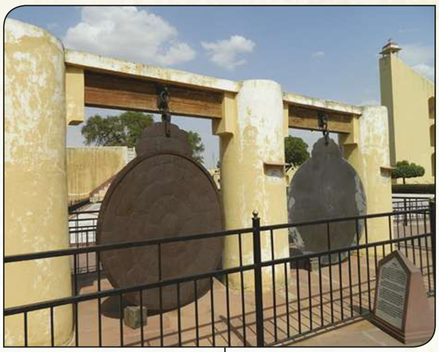
Jai Prakash Yantra

This instrument was designed to observe the position of the Sun and has a diameter of nearly 5.5m. It is a concave, hemispherical bowl with a metal plate suspended in the centre by crosshairs. The wires are stretched north to south and east to west, and the central plate can be used to determine the Sun's position by reading off where the shadow falls on the graduated chart marked on the instrument. Other heavenly bodies can be tracked too. Paths cut into the instrument allow observers to walk around inside it until the object overhead is aligned with the suspended plate. Their position within the instrument is then read off from the markings on its hemispherical bowl.

Vrihat Samrat Yantra

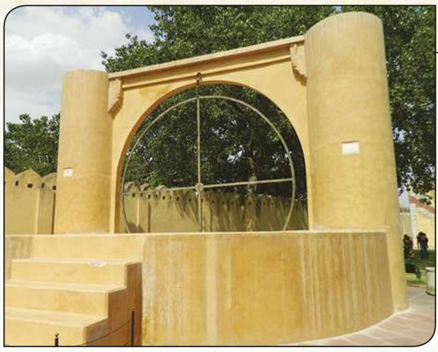
The Vrihat Samrat Yantra or 'supreme instrument' is the biggest in Jaipur, created to record the time. It is believed to be the biggest sundial in the world and can give the time to an accuracy of two seconds. The structure is a 27.5m high and 45m long triangle. Its hypotenuse is parallel to the Earth's axis and acts as a gnomon, the part of the sundial that casts the shadow. On each side of the gnomon is a quarter circle, inclined to the plane of the equator. The quadrants are divided into six hours each to represent morning and afternoon, then further split into 15 minutes and then again into one minute parts. A minute is divided into 10 sub-divisions of six seconds each.





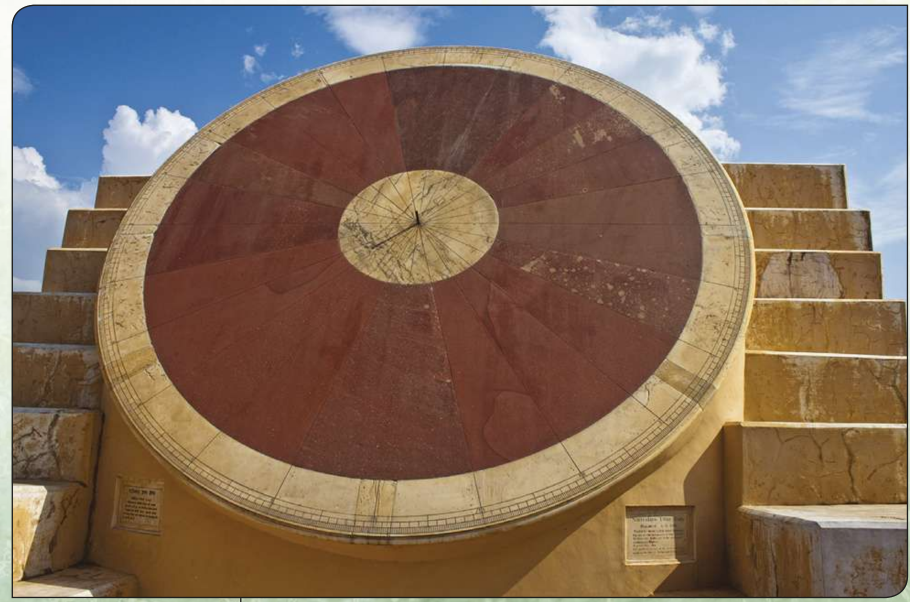
Yantra Raj

The Yantra Raj is a giant astrolabe for observing ascendants, altitudes and the position of the Sun and other celestial bodies. It consists of two circular discs, made from seven alloys to prevent it warping in different weather conditions. It is believed that Jai Singh was quite fascinated with the study of astrolabes and Yantra Raj is the result of compiling a number of them.



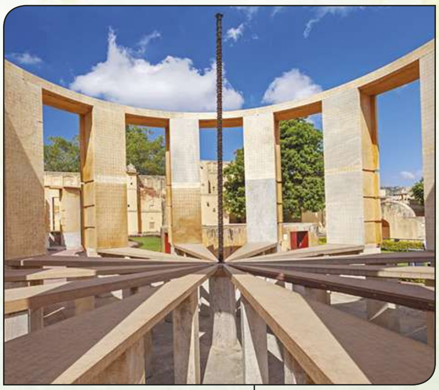
Unnatamsa

'Unnat' means elevated in Sanskrit while 'amsa' is division or degree of arc. This instrument is a large graduated brass circle, which is hung vertically from a supporting beam and allowed to rotate freely. There are two cross beams, one vertical and the other horizontal. At the meeting point of the two a tube can be moved vertically to align it to any celestial object. The rim of the brass circle allows the angle of the device to be measured to an accuracy of a 1/10th of a degree.



Nadivalaya

Nadivalaya was designed for measuring the time and the movement of the Sun across the equator. It is comprised of two circular plates that are parallel to the equator, facing north and south. Iron rods emerge perpendicular to the centre, and parallel to the axis of Earth's rotation, to act as gnomons. The two plates are used at different times of the year. The dial plate facing south is sunlit from the autumn equinox to the spring equinox and tells the time. The rest of the year the northern face is used. However on the date of the equinox itself the Sun illuminates both faces.



Ram Yantra

This instrument of two identical stone structures measures altitudes and azimuths. Each building possesses a cylindrical pillar at the centre and an outer wall split into 12 columns, themselves connected to the pillar by stone triangles. These are graduations, so that the position of the Sun can be determined by reading off the position of the central pillar's shadow. The position of stars can be determined by aligning the star with the top of the pillar and then reading off the position of the observer's eye.

ABOUT THE WRITER

Khursheed Dinshaw is a travel and lifestyle writer, based in India. Her work and photos appear in Indian and international magazines.

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PETE LAWRENCE

PLUS

Stephen Tonkin's
BINOCULAR TOUR
Turn to page 58 for six of this month's best binocular sights

The Sky Guide March

The magnificent and detail-packed planet Jupiter reaches opposition on 8 March and around this time the planet is optimally placed for telescope viewing. As an added bonus there are some fantastic interactions between the planet and its largest moons to look out for this month too.

Written by Pete Lawrence

Pete Lawrence is an expert astronomer and astrophotographer with a particular interest in digital imaging. As well as writing *The Sky Guide*, he appears on *The Sky at Night* each month on BBC Four.

Highlights

Your guide to the night sky this month

📷 This icon indicates a good photo opportunity

1

TUESDAY ▶

📷 The waning gibbous Moon (58% lit) is 4.75° from Mars at 02:20 UT this morning. Look for them low in the southeast. The Moon reaches its last quarter phase – one of two this month – at 23:12 UT.

Jupiter's moon Callisto can be seen casting a shadow on the planet's disc from 03:02 UT to 06:22 UT.

2

WEDNESDAY

📷 This morning the waning crescent Moon (47% lit) is slightly less than 3° north of mag. +0.9 Saturn. Both objects are visible low in the south-southeast at 04:50 UT.

8

TUESDAY

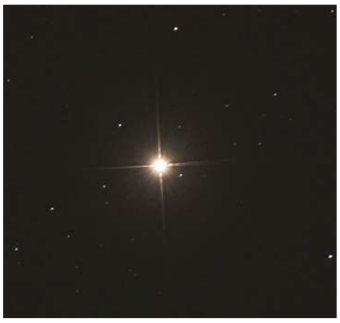
📷 Jupiter is at opposition today. Opposition is the time a planet reaches a position in the sky that is opposite the Sun. Between 00:31 UT and 01:54 UT there will also be two moons (Europa and Io) and two moon shadows on Jupiter's disc. At opposition, the shadows appear in line with their moons.

9

WEDNESDAY ▶

📷 It may be possible to see a very thin (1%) waxing crescent Moon just after sunset. See page 51.

Ganymede will be casting a shadow on Jupiter's disc as the sky begins to darken. The event is over by 19:14 UT.



14

◀ MONDAY

📷 At 13:30 UT, mag. +0.8 Aldebaran (Alpha (α) Tauri) will lie 27 arcminutes from the centre of the crescent Moon (37% lit). Look one-third of the way up the sky in the east-southeast. Once you've found the Moon, look for the star north of the lunar crescent using binoculars or a telescope.

15

TUESDAY

📷 The Galilean moons Io and Europa will be crossing Jupiter's disc along with their shadows this morning. The double moon and shadow transit starts at 02:20 UT and ends at 04:10 UT, when Europa exits the disc.

16

WEDNESDAY

Tonight sees comet C/2013 US10 Catalina officially pass into Perseus. The comet is expected to have faded to around mag. +9.5.

📷 Ganymede, Io and their shadows will be transiting Jupiter together between 20:51 UT and 22:09 UT.

22

TUESDAY

📷 The Moon is just 2.75° from mag. –2.3 Jupiter at 02:30 UT. Though the Moon will be virtually full (98% lit), the planet will stand out well.

📷 Io and Europa can be seen transiting Jupiter's disc together with their shadows this morning from 04:24 UT.

27

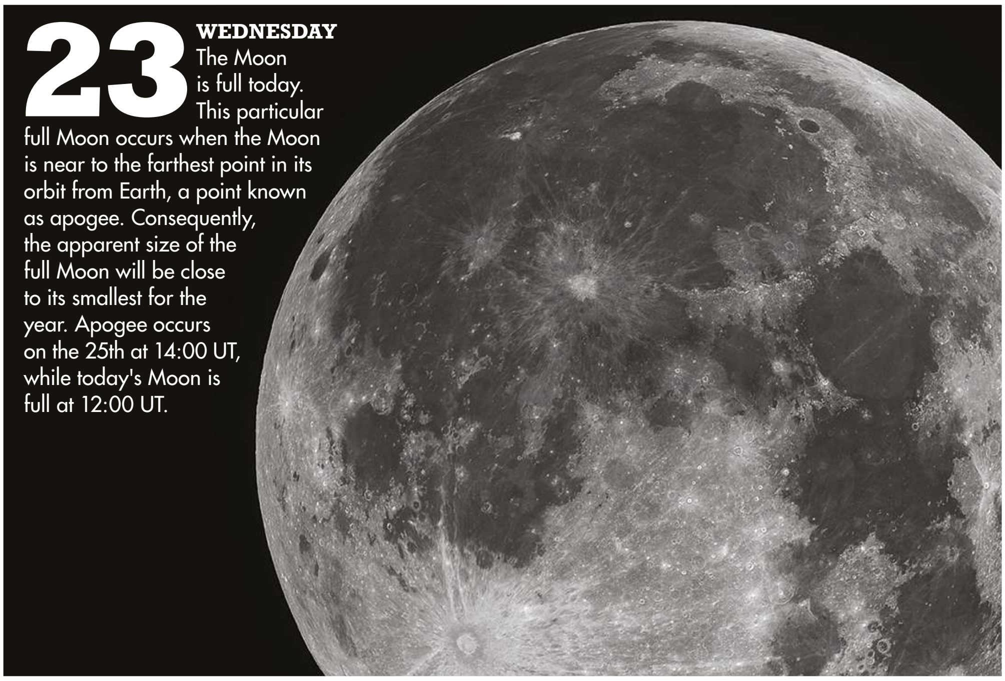
SUNDAY

We've reached that time again: this morning at 01:00 UT, the clocks go forward one hour as British Summer Time begins. The local time at 01:00 UT therefore becomes 02:00 BST.

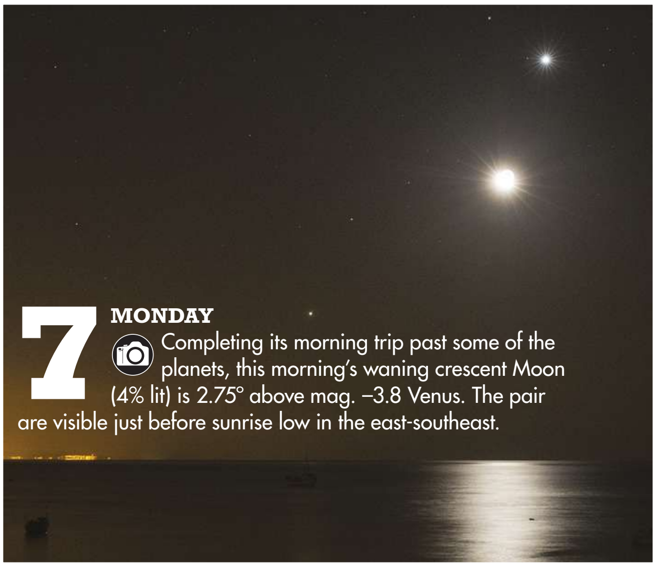
23

WEDNESDAY

The Moon is full today. This particular full Moon occurs when the Moon is near to the farthest point in its orbit from Earth, a point known as apogee. Consequently, the apparent size of the full Moon will be close to its smallest for the year. Apogee occurs on the 25th at 14:00 UT, while today's Moon is full at 12:00 UT.



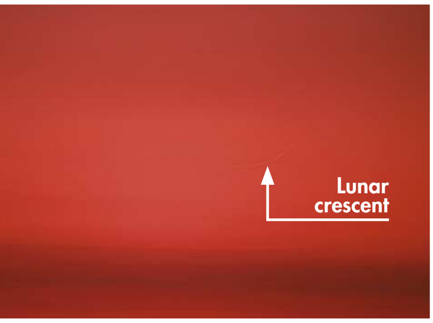
PETE LAWRENCE X 6



7

MONDAY

📷 Completing its morning trip past some of the planets, this morning's waning crescent Moon (4% lit) is 2.75° above mag. –3.8 Venus. The pair are visible just before sunrise low in the east-southeast.



13

SUNDAY

Look out for the triangular pattern of stars known as Melotte 111 due south, around two-thirds of the way up the sky at 01:00 UT. In legend this open cluster used to represent the tail of Leo the Lion but was later redesignated as the constellation of Coma Berenices.

17

THURSDAY

📷 Callisto, the outermost Galilean moon, can be seen transiting Jupiter's disc from 19:15 UT until 21:46 UT. Perhaps more impressive will be the moon's shadow transit which occurs between 21:03 UT on the 17th and 00:14 UT on the 18th.

20

SUNDAY

The bright star lying just above the Moon as darkness falls is mag. +1.4 Regulus (Alpha (α) Leonis).

At 04:30 UT the centre of the Sun will cross the celestial equator, a point in time known in the northern hemisphere as the spring equinox.

24

THURSDAY ▶

📷 Comet C/2013 US10 Catalina passes slightly to the east of open cluster NGC 1528 in Perseus.

Another double moon and moon-shadow transit occurs on Jupiter. This time its Io and Ganymede, between 23:51 UT on the 23rd and 00:34 UT this morning.

29

TUESDAY

📷 The waning gibbous Moon (73% lit) is 5° from Mars and 6.5° from Saturn at 04:00 BST (03:00 UT) this morning.

📷 Comet C/2013 US10 Catalina lies very close to mag. +6.2 open cluster NGC 1545 in Perseus in this morning's sky.

31

THURSDAY

The Moon reaches its second last quarter phase of the month at 16:18 BST (15:18 UT).

What the team will be observing in March

Pete Lawrence "Jupiter at opposition is hard to resist and just to sweeten the deal even further, there are a number of impressive double transits of some of the Galilean moons and their shadows to look forward to as well."

Paul Money "I love close encounters between planets and stars so will look out for Jupiter near Sigma Leonis on the 2nd and for Mars close to Beta Scorpii on the 16th."

Chris Bramley "There are two things on my must-see list in March. Jupiter obviously, and I'm also looking forward to getting lost in the stars of the Beehive Cluster."

Need to know

The terms and symbols used in *The Sky Guide*

UNIVERSAL TIME (UT) AND BRITISH SUMMER TIME (BST)

Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT.

RA (RIGHT ASCENSION) AND DEC. (DECLINATION)

These coordinates are the night sky's equivalent of longitude and latitude, describing where an object lies on the celestial 'globe'.

HOW TO TELL WHAT EQUIPMENT YOU'LL NEED

NAKED EYE
Allow 20 minutes for your eyes to become dark-adapted

BINOCULARS
10x50 recommended

PHOTO OPPORTUNITY
Use a CCD, planetary camera or standard DSLR

SMALL/MEDIUM SCOPE
Reflector/SCT under 6 inches, refractor under 4 inches

LARGE SCOPE
Reflector/SCT over 6 inches, refractor over 4 inches

Getting started in astronomy

If you're new to astronomy, you'll find two essential reads on our website. Visit http://bit.ly/10_Lessons for our 10-step guide to getting started and http://bit.ly/First_Tel for advice on choosing your first scope.

DON'T MISS...

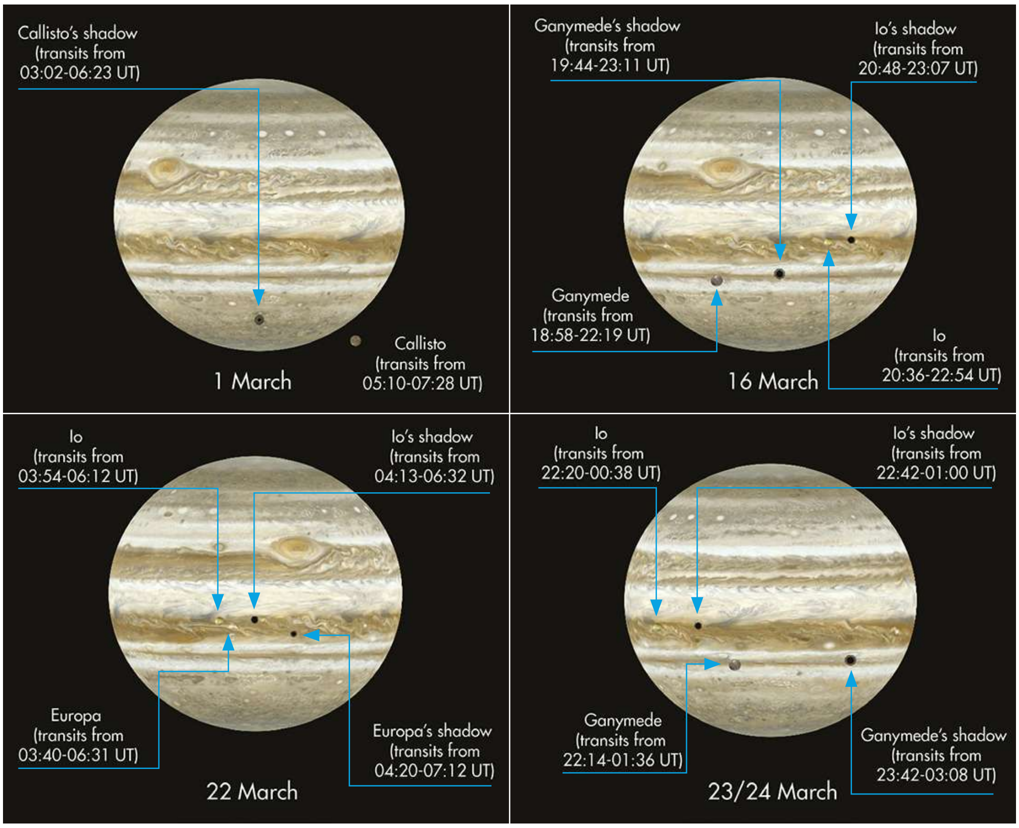
3 top sights

Jovian moon and shadow transits

WHEN: Throughout the month at the times specified

NEED TO KNOW

An object's brightness is given by its magnitude. The lower the number, the brighter the object: with the naked eye you can see down to mag. +6.0.


Callisto's shadow (transits from 03:02-06:23 UT)
Callisto (transits from 05:10-07:28 UT)
1 March
Ganymede's shadow (transits from 19:44-23:11 UT)
Io's shadow (transits from 20:48-23:07 UT)
Ganymede (transits from 18:58-22:19 UT)
Io (transits from 20:36-22:54 UT)
16 March
Io (transits from 03:54-06:12 UT)
Io's shadow (transits from 04:13-06:32 UT)
Europa (transits from 03:40-06:31 UT)
Europa's shadow (transits from 04:20-07:12 UT)
22 March
Io (transits from 22:20-00:38 UT)
Io's shadow (transits from 22:42-01:00 UT)
Ganymede (transits from 22:14-01:36 UT)
Ganymede's shadow (transits from 23:42-03:08 UT)
23/24 March

An eyepiece view (south is up) of some of the exciting moon and moon-shadow transits visible during March

JUPITER IS A wonderful planet to look at through a telescope because its disc is large enough to show some tantalising atmospheric detail. Another highlight is the quartet of Galilean moons – Io, Europa, Ganymede and Callisto – which constantly dance around Jupiter's globe.

Lying more-or-less in Jupiter's equatorial plane, from Earth we get to see some interesting interactions between these moons and the planet. One of the most impressive is the passage of a moon and its shadow across the cloud tops of Jupiter below. This month there are a number of these events worth looking out for.

Right at the start of the month on 1 March, it will be possible to see the shadow cast by the outermost Galilean moon, Callisto. The transit of this shadow will be visible between 03:02 UT and 06:22 UT, with the moon itself transiting the northern portion of Jupiter between 05:11 UT and 07:28 UT.

There's a lovely double transit involving the moons Io and Europa on 8 March, the date Jupiter reaches opposition. At this point, the shadows cast by the moons will be in line with their respective discs, appearing slightly south of them. Both moons and shadows will be fully in transit between 00:31-01:54 UT.

On 9 March as the sky is darkening and Jupiter rising, you should be able to spot the shadow of the giant moon Ganymede in transit. As Ganymede slips off the limb at 18:57 UT, Io and its shadow will be starting their transit on the opposite side. Ganymede's shadow will have fully left the disc by 19:14 UT.

There are a couple of noteworthy events starting on 15 March, with Io and Europa once again involved in a double transit. Both moons and both shadows will be on disc from 02:20 UT to 04:10 UT. Another double event occurs on the night of 16 March, when between 20:51 UT and 22:09 UT, Io, Ganymede and their shadows will be fully on Jupiter's disc. It will be interesting to compare the sizes of Io's shadow with that of giant Ganymede.

On 17 March Callisto can be seen in transit between 19:15 UT and 21:45 UT. Its shadow follows suit, crossing Jupiter's disc between 21:02 UT and 00:14 UT on 18 March. The shadow appears almost as Callisto has reached the other side of Jupiter.

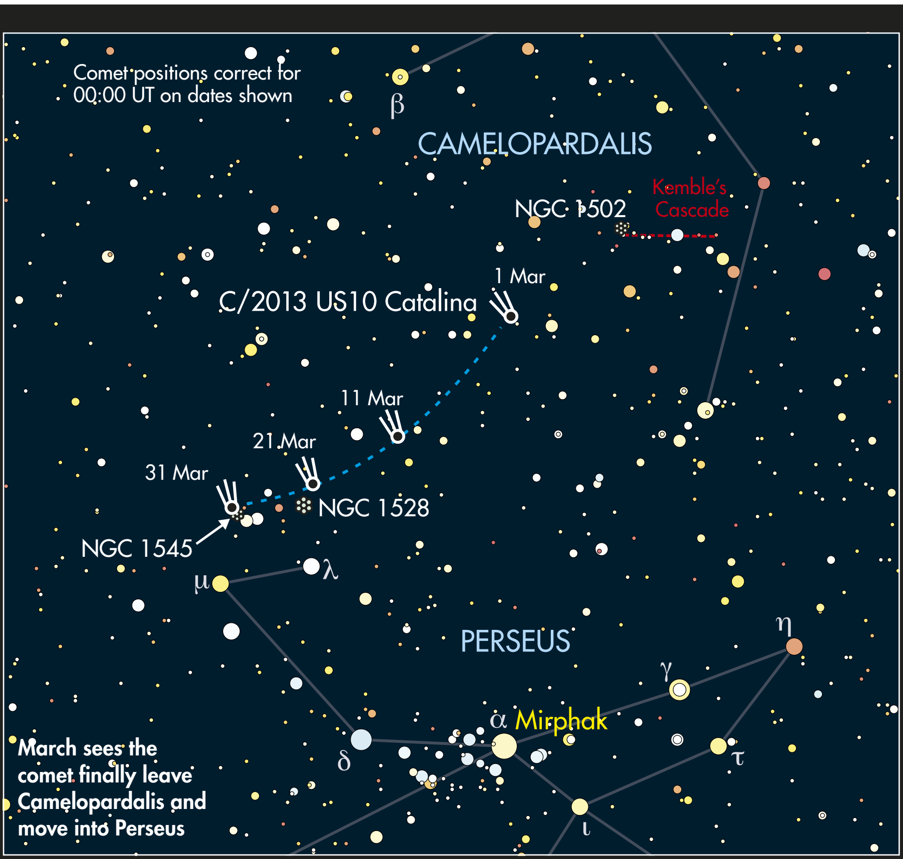
Two further impressive double transits can be seen: on 22 March starting at 04:24 UT between Io and Europa; and from 23:51 UT on 23 March until 00:34 UT

The inky blackness of the moon shadows are unmistakable against the Jovian surface

PETE LAWRENCE X4

Comet C/2013 US10 Catalina passes into Perseus

WHEN: All month, but Moon interferes on 17-26 March


Comet positions correct for 00:00 UT on dates shown
β
CAMELOPARDALIS
NGC 1502
Kemble's Cascade
1 Mar
C/2013 US10 Catalina
11 Mar
21 Mar
31 Mar
NGC 1528
NGC 1545
μ
λ
PERSEUS
η
γ
α Mirphak
δ
τ
ι
March sees the comet finally leave Camelopardalis and move into Perseus

FADING COMET C/2013 US10 Catalina remains an easy small telescope target at the start of March, but becomes trickier to see with anything less than an 8-inch aperture by the end of the month.

On the 1st, the mag. +9.5 comet will be in Camelopardalis, a little south of NGC 1502, the open cluster located at one end of the asterism known as Kemble's Cascade. By the middle of the month, it will have faded to mag. +10.5, but as it does it will be passing from the tricky to navigate constellation of the Giraffe into the much better defined Perseus.

On 23 March the mag. +10.8 comet will swing close to mag. +6.4 open cluster NGC 1528, brushing past the cluster's eastern edge. It then continues south for an even closer encounter with the mag. +6.2 open cluster NGC 1545 at the end of March. At this time the comet will be around mag. +11.1; being an extended object, it will show lower surface brightness than this figure would suggest. Consequently, this will make it that bit harder to pick up.

You shouldn't have much bother if you're hoping to image the comet though. In fact, because the comet will now be moving relatively slowly against the background stars you will be able to take longer exposures of it without significant motion blur.

Comet C/2013 US10 Catalina is an Oort Cloud comet, coming in from the extreme outer regions of our Solar System for a one time pass of the Sun. If you've not seen it already then this is the time to try before it fades too much.

Chasing the thin Moon

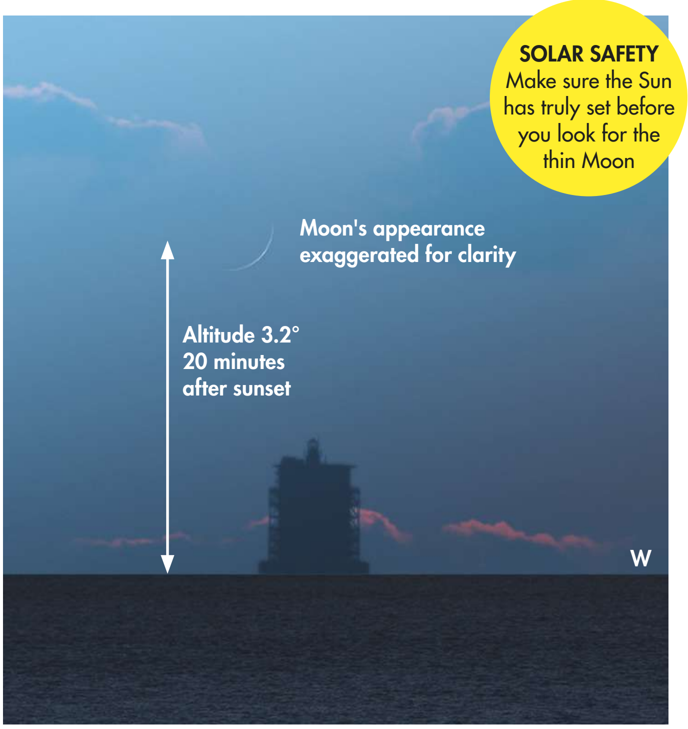
WHEN: 9 March, from 15 minutes after sunset

THE MOON IS probably the easiest object to spot in the night sky. However, move it into a daylight sky and the task gets that bit harder. Larger phases are still relatively easy to pick out from the blue background, but thin crescents are much more challenging.

The hardest to spot is the thin crescent that occurs just after or before new Moon. At this time of year, conditions are optimal for spotting thin evening crescents.

This month's new Moon occurs at 01:55 UT on the 9th. By the time the Sun is setting (around 18:00 UT from the centre of the UK) the separation between the Sun and the Moon will be around 8.5° leading to a moonset approximately 50 minutes after sunset.

Using binoculars, take a look at the region of sky low in the west after the Sun has completely set and see if you can see this incredibly delicate sliver of moonlight. If you do manage to pick it up, carefully move the binoculars down to locate a feature on the horizon directly below the crescent. Then, without binoculars, using the feature as a reference, see if you can spot it with just your eyes!


SOLAR SAFETY Make sure the Sun has truly set before you look for the thin Moon

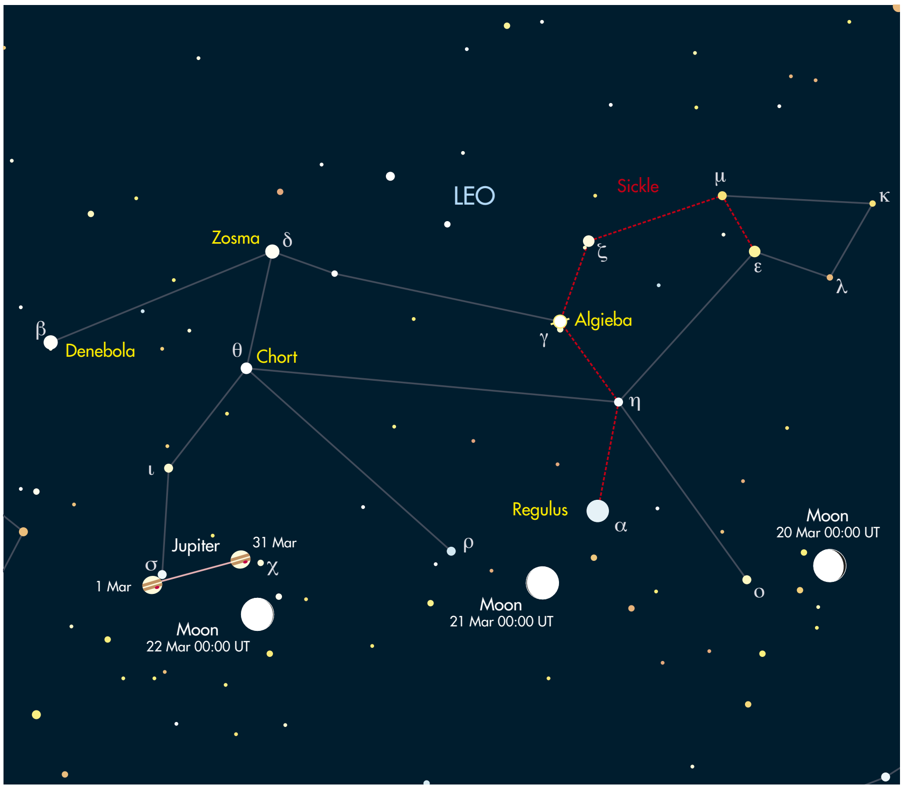
You have a short window after sunset to look for this slender crescent

The planets

PICK OF THE MONTH

JUPITER

BEST TIME TO SEE: 8 March 00:30 UT
ALTITUDE: 44°
LOCATION: Leo
DIRECTION: South
FEATURES: Belts, moons, Great Red Spot, intricate atmospheric features
EQUIPMENT: 3-inch or larger scope



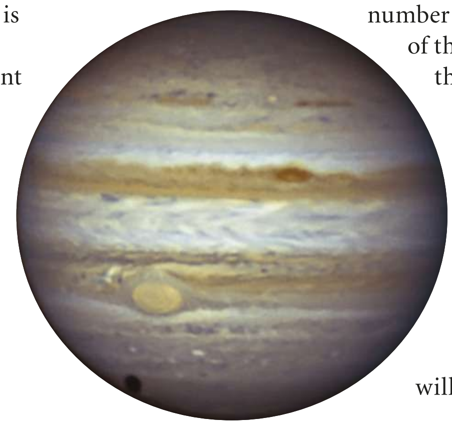
Jupiter resides in Leo throughout March; look for its brilliant disc near the Lion's back paw

JUPITER REACHES OPPOSITION on 8 March, a time when it'll be in the opposite part of the sky to the Sun. This is an optimum arrangement for Jupiter as it represents a time when it appears at its largest and brightest to us. This year, Jupiter will present a disc that is 44 arcseconds across. In planetary terms, this is second only to Venus when in a thin crescent phase, and so presents a fantastic opportunity to spot some of the tantalising details on Jupiter's globe.

It's important to realise that opposition is not a short-term effect and Jupiter has looked and will continue to look good through a telescope for a number of weeks either side of this date. At mag. –2.6, the planet is bright, and dominates the east portion of Leo the Lion. It currently sits close to mag. +4.0 Sigma (σ) Leonis, which marks the Lion's back paw.

A 4-inch telescope will show lots of detail on the planet's disc including the persistent storm known as the Great Red Spot. The key to seeing features like this and the prominent belts that encircle the globe is to give your eye time to relax into the view. It's not uncommon to look through the eyepiece and see a bright relatively featureless blob at first. However, if you give your eye time to get used to the view, subtle detail can start to appear.

As well as the detail that's on show in Jupiter's atmosphere, the four largest Galilean moons are doing some interesting things this month too. These are fascinating to watch as they dance around their giant planetary host. Turn to page 50 to find out more.

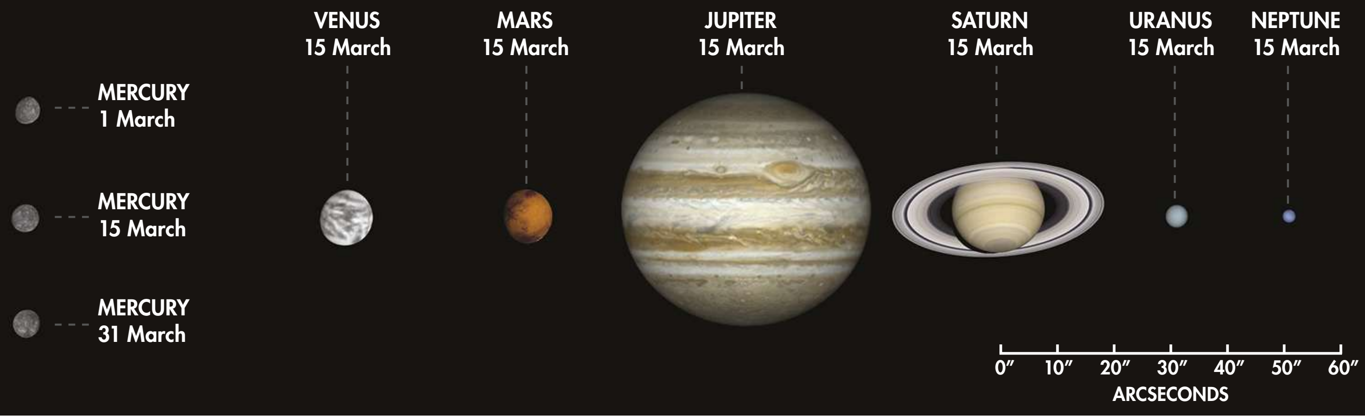


Jupiter's opposition puts it at its biggest and brightest for the current apparition

PETE LAWRENCE X 3

THE PLANETS IN MARCH

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope



MARS

BEST TIME TO SEE: 31 March 04:50 BST (03:50 UT)
ALTITUDE: 16°
LOCATION: Scorpius
DIRECTION: South

Things are now starting to get rather exciting as far as Mars is concerned. On the 1st it presents an 8.7-arcsecond disc. However, by the end of March, this figure will have grown to 11.7 arcseconds, which is a significant rise. This will be coupled with the planet getting brighter too, from mag. +0.3 to –0.6 over the same period.

The only downside to this rapid improvement will be the planet's low altitude as seen from the UK. Mars moves from Libra into Scorpius over the month, ending 6° from its celestial rival, the mag. +1.1 red supergiant Antares (Alpha (α) Scorpii). If you get a steady night, it'll definitely be worth pointing a telescope at Mars to see if you can make out any surface features. These include the north polar cap and rocky areas which contrast with the planet's deserts.

SATURN

BEST TIME TO SEE: 31 March, 05:00 BST (04:00 UT)
ALTITUDE: 15°
LOCATION: Ophiuchus
DIRECTION: Just east of south

Saturn is a morning object almost reaching its highest point in the sky, due south, in darkness at the end of the month. Saturn is in Ophiuchus, not too far from Mars; on the 31st they will appear separated by 9°. Yellow-hued Saturn will be to the east of Mars, shining away at mag. +0.5.

If you can get a telescope on Saturn at the moment, the view is quite glorious as the ring system is very wide open. It's Saturn's northern pole that's currently tilted toward us and this should be very evident if the sky conditions are stable. Like Jupiter, Saturn also has an impressive family of brighter moons that can be seen in a small scope. The brightest of these is Titan, a mysterious world shrouded in a thick atmosphere.

MERCURY

BEST TIME TO SEE: 31 March, 20 minutes after sunset
ALTITUDE: 3° (low)
LOCATION: Pisces
DIRECTION: West

At the start of March Mercury also rises around the same time as the Sun despite being reasonably well separated from it, and this makes it hard to see. Superior conjunction, when Mercury lines up with the Sun on the far side of its orbit relative to Earth, occurs on 23 March after which time the planet will re-emerge in the evening sky. Mercury should be easier to spot in the evening twilight. Look for it at the end of the month, around 20 minutes after sunset low in the west. The mag. –1.3 planet sets around 50 minutes after the Sun on 31 March.

VENUS

BEST TIME TO SEE: 1 March, 30 minutes before sunrise
ALTITUDE: 1.5° (low)
LOCATION: Capricornus
DIRECTION: East-southeast

Venus shines at a brilliant mag. –3.9 but despite this is tricky to see in the morning sky. This is because it lies really close to the horizon as the Sun comes up.

URANUS

BEST TIME TO SEE: 1 March
ALTITUDE: 12°
LOCATION: Pisces
DIRECTION: West

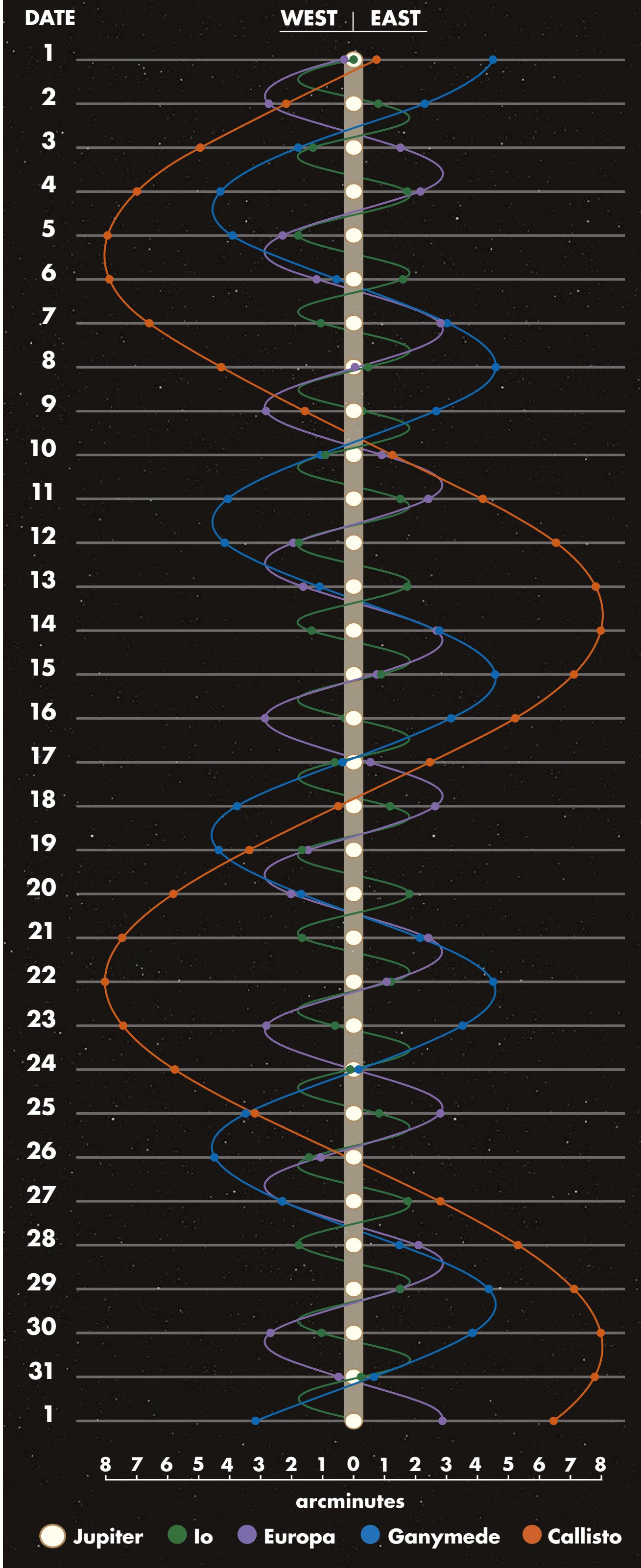
Uranus, currently in Pisces, is visible at the start of the month but rapidly loses position to the evening twilight by the end of March.

NOT VISIBLE THIS MONTH
NEPTUNE

YOUR BONUS CONTENT Planetary observing forms

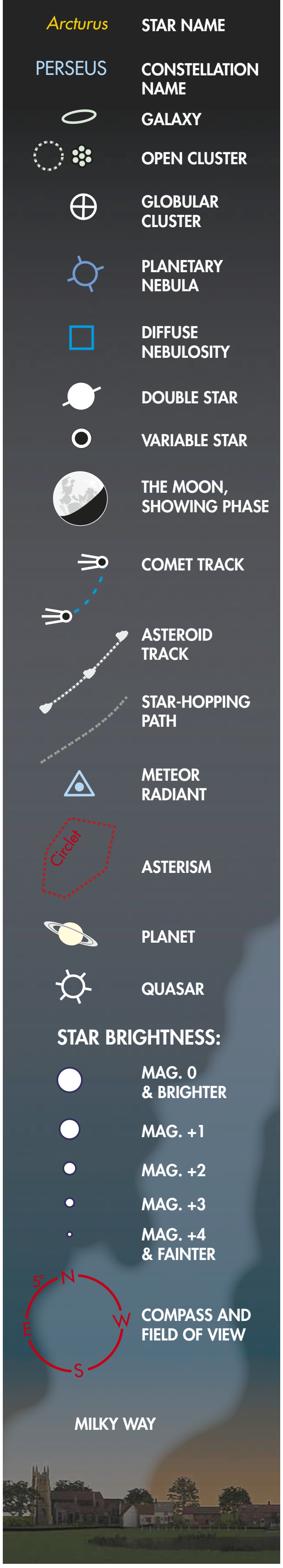
JUPITER'S MOONS
March

Using a small scope you'll be able to spot Jupiter's biggest moons. Their positions change dramatically during the month, as shown on the diagram. The line by each date on the left represents 00:00 UT.



The Northern Hemisphere

KEY TO STAR CHARTS



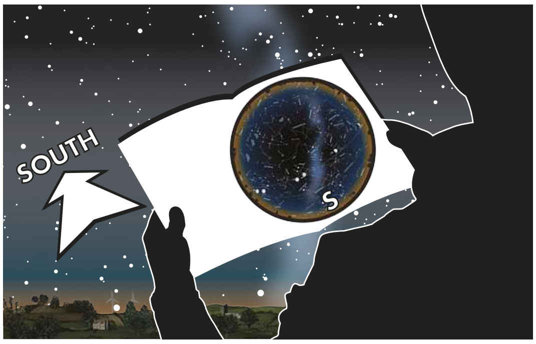
WHEN TO USE THIS CHART

1 MARCH AT 00:00 UT
15 MARCH AT 23:00 UT
31 MARCH AT 23:00 BST

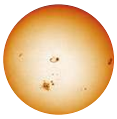
On other dates, stars will be in slightly different places due to Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

HOW TO USE THIS CHART

1. **HOLD THE CHART** so the direction you're facing is at the bottom.
2. **THE LOWER HALF** of the chart shows the sky ahead of you.
3. **THE CENTRE OF THE CHART** is the point directly over your head.



THE SUN IN MARCH*



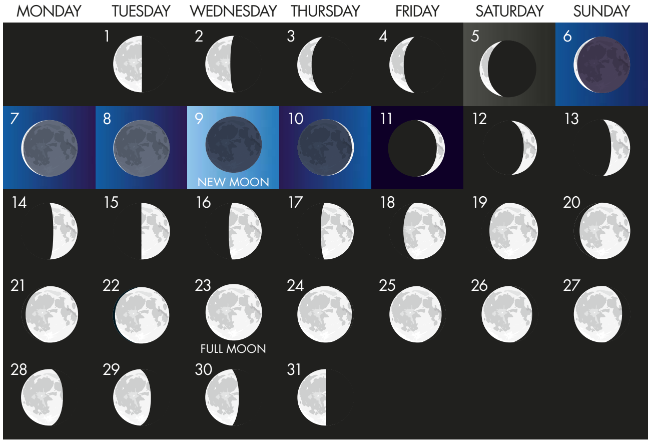
DATE	SUNRISE	SUNSET
1 Mar 2016	06:56 UT	17:48 UT
11 Mar 2016	06:33 UT	18:07 UT
21 Mar 2016	06:09 UT	18:26 UT
31 Mar 2016	06:45 BST	19:44 BST

THE MOON IN MARCH*

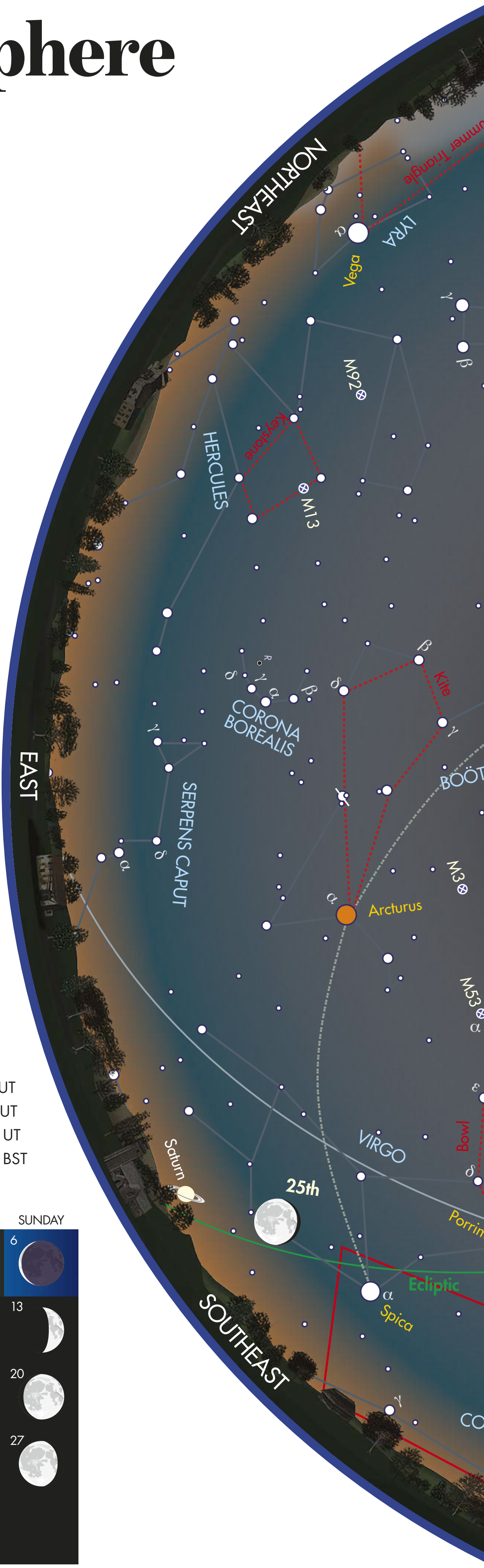
MOONRISE TIMES

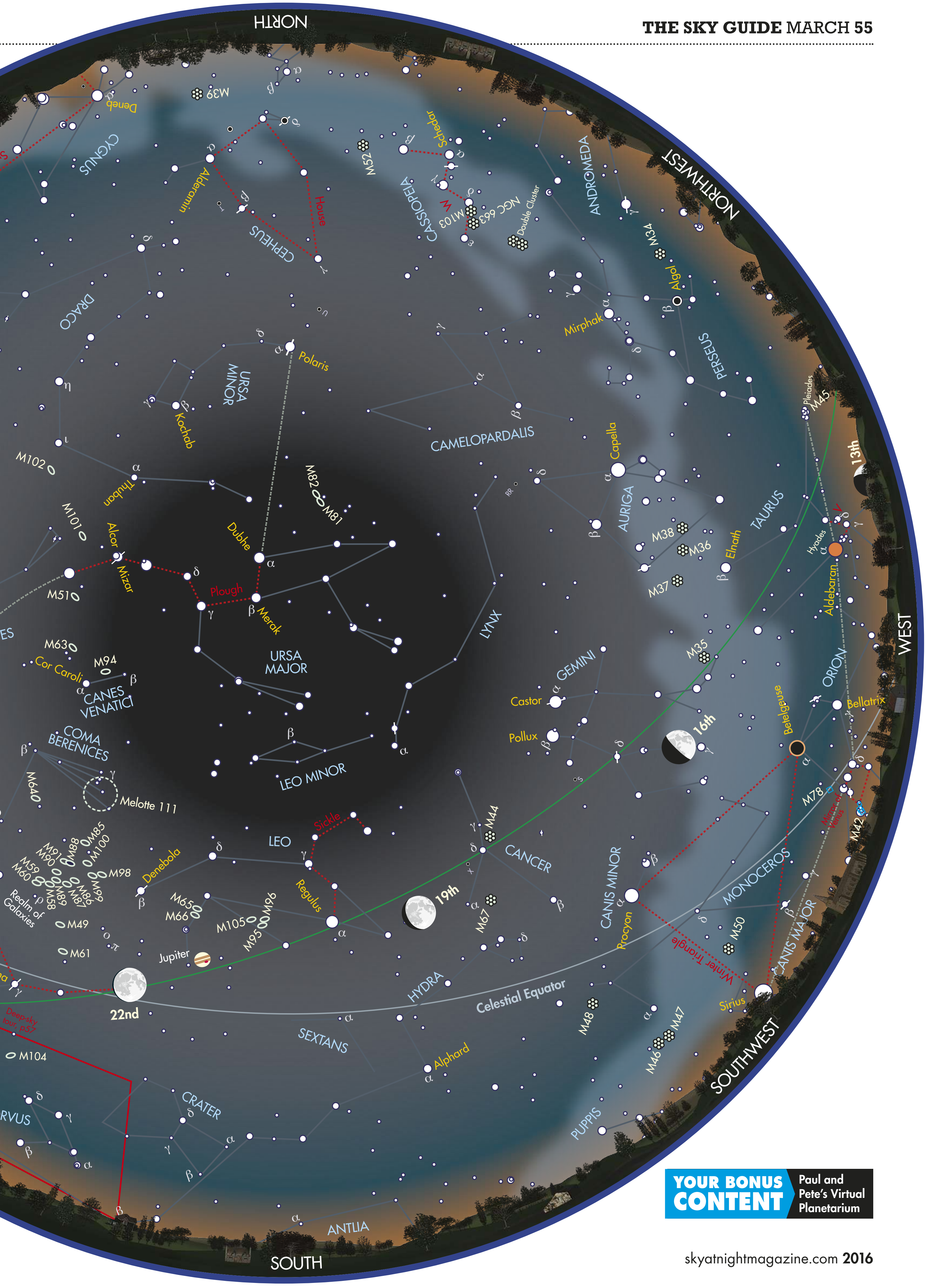
1 Mar 2016, 00:58 UT
5 Mar 2016, 04:32 UT
9 Mar 2016, 06:49 UT
13 Mar 2016, 08:53 UT
17 Mar 2016, 12:10 UT
21 Mar 2016, 16:28 UT
25 Mar 2016, 20:45 UT
29 Mar 2016, 00:49 BST

*Times correct for the centre of the UK



MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
	1	2	3	4	5	6
7	8	9 NEW MOON	10	11	12	13
14	15	16	17	18	19	20
21	22	23 FULL MOON	24	25	26	27
28	29	30	31			



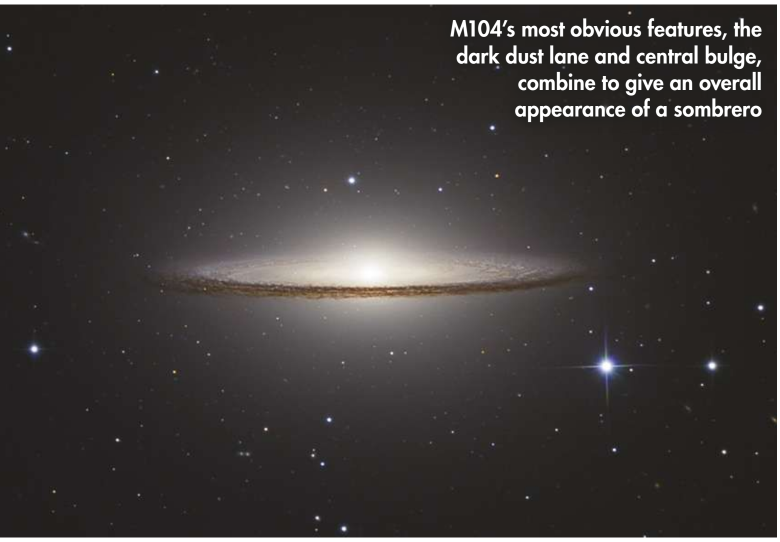


YOUR BONUS CONTENT Paul and Pete's Virtual Planetarium

Deep-sky tour

This month's targets can all be found near the distinctly unavian sail of Corvus, the Crow

☑ Tick the box when you've seen each one



M104's most obvious features, the dark dust lane and central bulge, combine to give an overall appearance of a sombrero

NGC 5068

NGC 5068 is a mag. +10.6 face-on barred spiral galaxy located 2° north of mag. +3.0 Gamma (γ) Hydrae, itself 12° south of mag. +1.0 Spica (Alpha (α) Virginis). The galaxy is located in the constellation of Virgo, 22 million lightyears away. It is what's known a 'field' galaxy; a galaxy that doesn't belong to a galaxy cluster, and so is essentially gravitationally isolated and left to its own devices. It's a relatively large one too at 6 arcminutes across, which translates into low surface brightness glow when viewed with a 6-inch scope. Larger instruments reveal it to be granular but without any distinct core. ☐ **SEEN IT**

M68

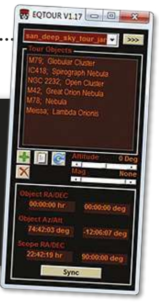
Recentre on Gamma Hydrae and slew 10° west to find mag. +2.7 Kraz (Beta (β) Corvi). Our next target, the globular cluster M68, is 3.5° south of this star. A 6-inch scope shows it as a haze with some of the outermost stars resolved. Using a low power (say 50x) with a 10-inch scope will add some granularity to the haze. Increase the magnification and the core resolves well. Larger scopes will reveal that the cluster possesses a brighter middle third. M68 is estimated to be 33,000 lightyears away and has a physical diameter of 106 lightyears. Also of interest nearby is the double star ADS 8612 (its components are mag. +5.4 and mag. +12.1), 45 arcminutes to the southwest. ☐ **SEEN IT**

NGC 4038/39

Extending a line from mag. +2.9 Algorab (Delta (δ) Corvi) through mag. +2.6 Gienah (Gamma (γ) Corvi) for the same distance will bring you to the area containing NGC 4038 and 4039, a pair of mag. +10.9 and +11.2 interacting galaxies. The immense gravitational forces at work here have pulled out two long, thin streams of stars that resemble an insect's antennae. Unsurprisingly, the pair is known as the Antennae Galaxies. An 8-inch scope will only show the northernmost brighter core of NGC 4038. Increasing the aperture to 10 inches reveals NGC 4039's core to the south. Seen together, both cores have a heart-shaped appearance. The faint tails emanating from both galaxies are hard to see but can be glimpsed in larger instruments if you use averted vision. ☐ **SEEN IT**

THIS DEEP-SKY TOUR HAS BEEN AUTOMATED

ASCOM-enabled Go-To mounts can now take you to this month's targets at the touch of a button, with our Deep-Sky Tour file for the EQTOUR app. Find it online.



san_deep_sky_tour_jar

Tour Objects

M79, Globular Cluster
IC418, Spirograph Nebula
NGC 2232, Open Cluster
M42, Great Orion Nebula
M78, Nebula
Meissa, Lambda Orionis

Altitude 0 Deg
Mag None

Object RA/DEC 00:00:00 hr 00:00:00 deg
Object Az/Alt 74:42:03 deg -12:06:07 deg
Scope RA/DEC 22:42:19 hr 90:00:00 deg

NGC 4027

NGC 4027 is a mag. +11.7 barred spiral galaxy located 41 arcminutes southwest of the Antennae Galaxies. More than that, it is quite possible that it's gravitationally interacting with its more famous neighbours. A 6-inch scope reveals only a small, circular grey smudge. An 8-inch instrument reveals that the smudge isn't circular but elongated. Larger scopes still will show a small, brighter core inside an outer elliptical halo. It's NGC 4027's bar that large telescopes see as the inner core. The galaxy is unusual in that it has one spiral arm extending much further out than the other. This is probably due to the gravitational forces of a galactic collision with the other members of the NGC 4038 Group. ☐ **SEEN IT**

NGC 4361

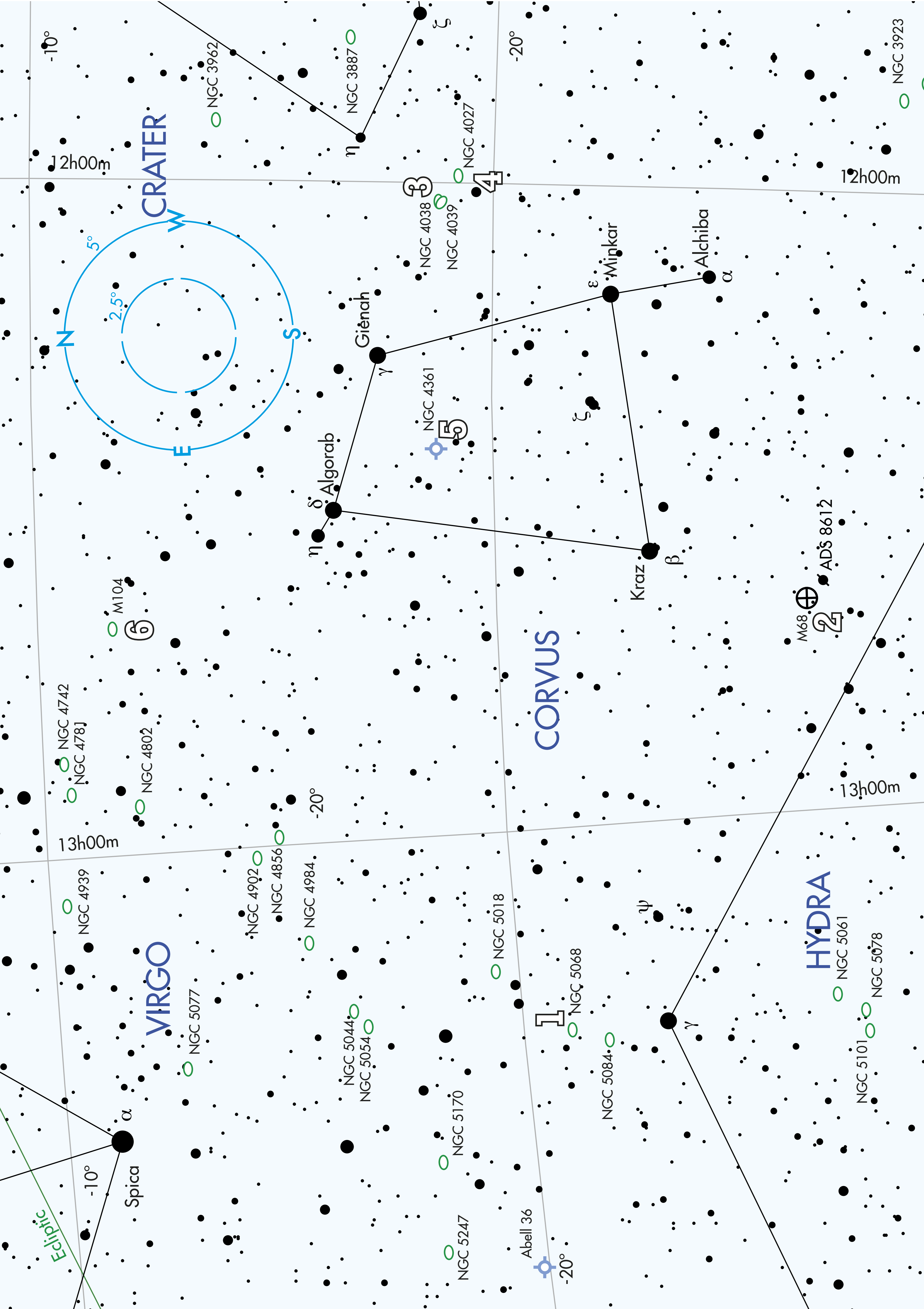
Our penultimate target is the 11th-magnitude planetary nebula known as NGC 4361. Relatively easy to find as it lies within the main quadrilateral of Corvus, known as 'The Sail', it lies three-quarters of the way along a line from mag. +4.0 Alchiba (Alpha (α) Corvi) towards mag. +4.3 Eta (η) Corvi. A 6-inch scope shows that it's a rather diffuse object, but also that it is a decent size. A 10-inch scope will reveal the mag. +13.0 central star, located within a brighter region 40 arcminutes across. This in turn is surrounded by a much fainter halo. The brighter portion of the nebula appears to extend into this halo to the north and south. ☐ **SEEN IT**

M104

Our final target is M104, the Sombrero Galaxy, which sits 28 million lightyears from Earth and is estimated to be around 30 per cent of the size of our own Milky Way. Imagine a line from mag. +5.2 Zeta (ζ) Corvi to Eta Corvi and carry on for approximately the same distance again – this will put you in the correct vicinity to see it. Located just over the border in Virgo, this mag. +8.3 galaxy is easy to see in any size of scope. A 6-inch instrument shows an elongated glow approximately 6x2 arcminutes in size, but its defining characteristic is a dark dust lane that cuts across the southern portion of the central halo. ☐ **SEEN IT**

YOUR BONUS CONTENT Print out this chart and take an automated Go-To tour

CHART: PETE LAWRENCE, PHOTO: JOHANNES SCHEDLER/CCDGUIDE.COM


CRATER
CORVUS
VIRGO
HYDRA
N
E
S
W
5°
2.5°
12h00m
12h00m
13h00m
13h00m
-10°
-10°
-20°
-20°
-20°
Ecliptic
NGC 3962
NGC 3887
NGC 4027
NGC 4038
NGC 4039
NGC 3923
NGC 4361
NGC 4742
NGC 4781
NGC 4802
NGC 4939
NGC 4902
NGC 4856
NGC 4984
NGC 5018
NGC 5068
NGC 5077
NGC 5044
NGC 5054
NGC 5084
NGC 5170
NGC 5247
NGC 5061
NGC 5078
NGC 5101
M104
M68
ADS 8612
Abell 36
Gienah
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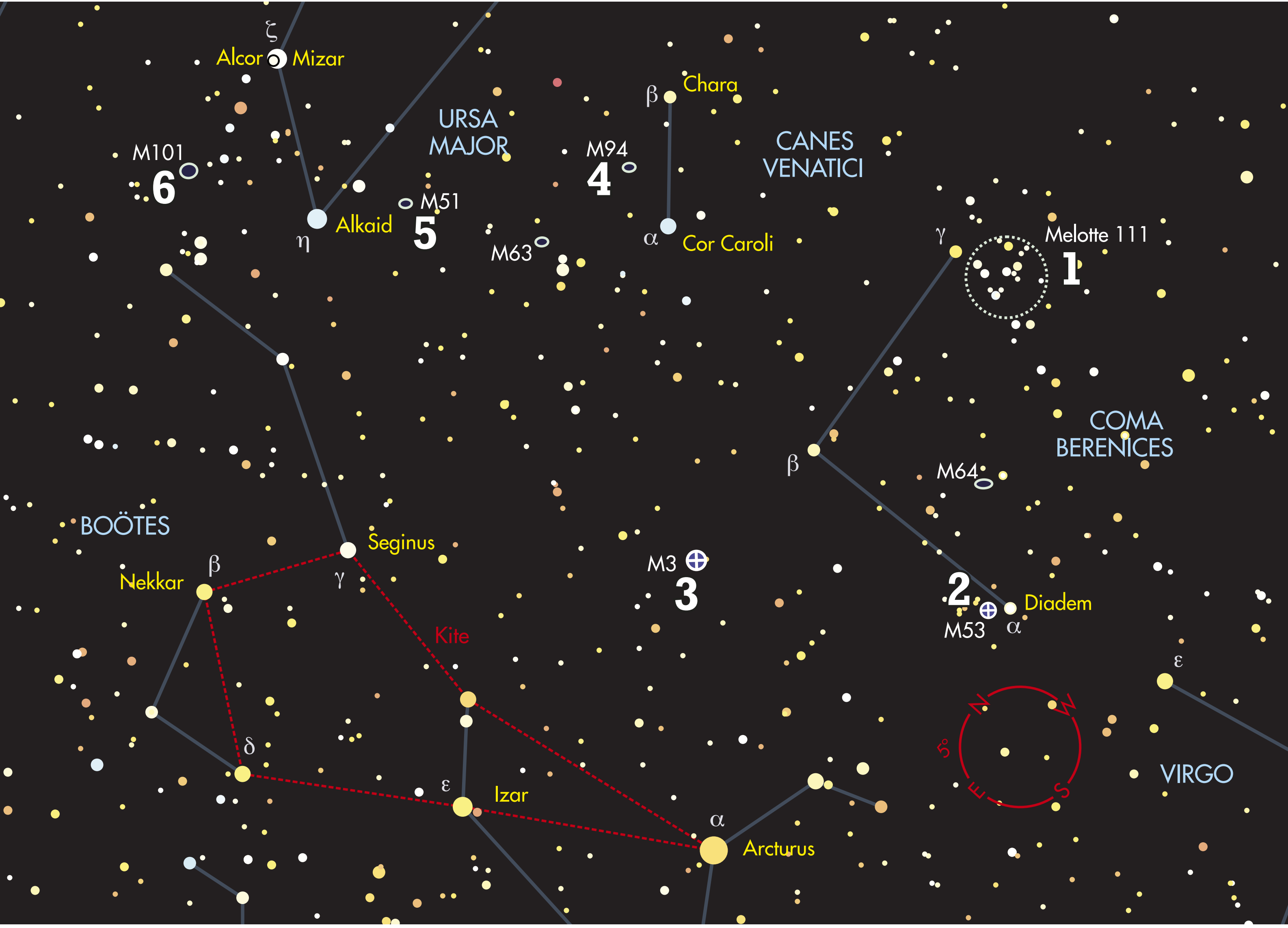
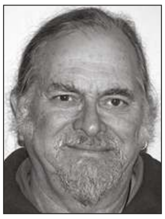




Binocular tour

March sees us scouring the skies of Boötes, Coma Berenices and Canes Venatici

With Stephen Tonkin

☑ Tick the box when you've seen each one

1 MELOTTE 111

10x 50 We start this month's tour with an object that seems to be made for binoculars. Start by identifying mag. +2.9 Cor Caroli (Alpha (α) Canum Venaticorum), then navigate 12° southwest to mag. +4.4 Gamma (γ) Comae Berenices, where you should be able to see a misty patch of sky. This is open cluster Melotte 111. It extends for nearly 6° and so will fill the field of view of a pair of 10×50 binoculars, which should resolve 30 or so stars. This cluster is unusual in having no stars fainter than mag. +10.5. ☐ **SEEN IT**

2 M53

15x 70 From Gamma Comae Berenices, navigate 15° to the southeast to find mag. +4.3 Diadem (Alpha (α) Comae Berenices). Hop a 1° to the northeast and you will see a small misty patch, which will appear to grow in fuzziness and brightness if you centre it in the field of view then avert your gaze back to Diadem or beyond. This is mag. +7.6 globular cluster, M53, and its apparent change in size and brightness is a good demonstration of the difference between direct and averted vision. ☐ **SEEN IT**

3 M3

10x 50 To find M3, you need to imagine two lines. The first joins Diadem to mag. +3.0 Seginus (Gamma (γ) Boötis), while the second joins Cor Caroli to mag. +0.2 Arcturus (Alpha (α) Boötis). They intersect in a relatively sparse region of sky, where you'll find mag. +6.2 M3. Although M3 is slightly more difficult to find than M53, it is both larger and brighter, making it very much easier both to see and to identify as a globular cluster. ☐ **SEEN IT**

4 M94

10x 50 For our first galaxy return to Cor Caroli and imagine a line between it and mag. +4.2 Chara (Beta (β) Canum Venaticorum). Look 1.5° away from the mid point of this line, towards the northeast, and you should find the faint glow of light that is the mag. +8.9 spiral galaxy M94. You may need to use averted vision. Like all galaxies, M94 benefits greatly from dark, transparent skies, so if you are unable to see it in a pair of 10×50s, either wait for better conditions or use larger binoculars: it is quite an easy spot with a pair of 15×70s in typical suburban skies. ☐ **SEEN IT**

5 M51

10x 50 Our next target is the famous Whirlpool Galaxy, and it is very easy to find. Imagine that a line from mag. +2.2 Mizar (Zeta (ζ) Ursae Majoris) to mag. +1.9 Alkaid (Eta (η) Ursae Majoris) is the upright of a letter L: M51 lies at the 'toe' of the L, 3.5° from Alkaid and directly in line with M94. What you are seeking is a tiny fuzzy patch, slightly smaller than M94. Charles Messier's original description, "a very faint nebula without stars", holds true with 10x50s, so don't expect to make out any structure beyond a slightly elongated appearance. ☐ **SEEN IT**

6 M101

15x 70 M101 can be quite a difficult object: use mounted binoculars under a Moonless, transparent sky, when the galaxy is above any skyglow, but not so high as to be awkward. To find it, imagine an equilateral triangle with Mizar and Alkaid as its base; M101 is just inside the third apex. Use averted vision and occasionally jiggle the binoculars. You should notice a small patch of sky that is very slightly brighter than the rest: your galaxy. Once you know what you are looking for, you should be able to find it at will. ☐ **SEEN IT**

CHARTS AND PICTURES: PETE LAWRENCE

Moonwatch

Reiner

REINER IS, AT first glance, an unremarkable 30km-wide crater in the Oceanus Procellarum. With a longitude of 55°W it is close enough to the lunar limb that it appears foreshortened into an ellipse from Earth. Seen directly from above, it would appear circular.

The crater's rim is well defined and not eroded in any significant way. Its floor is approximately 2.6km below the surface of the Oceanus Procellarum and contains a small central peak. Under a low Sun angle when the terminator is close by, it's possible to see the shadow caused by a roughly north-south aligned wrinkle ridge in the Oceanus Procellarum on which Reiner lies.

When the Sun is low in Reiner's sky, the slight elevation of its rim above the surface of the Oceanus Procellarum can produce a really dramatic shadow, with the many peaks and troughs in Reiner's rim producing sharp, jagged points. One particularly evocative description is that the shadow looks like one you'd expect to see cast by a fairytale castle covered in towers and spires.

The dark surface of the Oceanus Procellarum provides good contrast for some bright features prominent when the Sun is more overhead. A bright ejecta ray from crater Kepler (31km) reaches west across Procellarum and almost reaches Reiner; impressive considering that the centres of Reiner and Kepler are 500km apart. It's also interesting to compare how different Kepler and Reiner appear considering that they are of similar size. Younger Kepler still retains its bright ejecta rays, and these really help frame the crater and attract the eye towards it. Reiner's ejecta has faded over time. Consequently, the crater is easily overlooked.

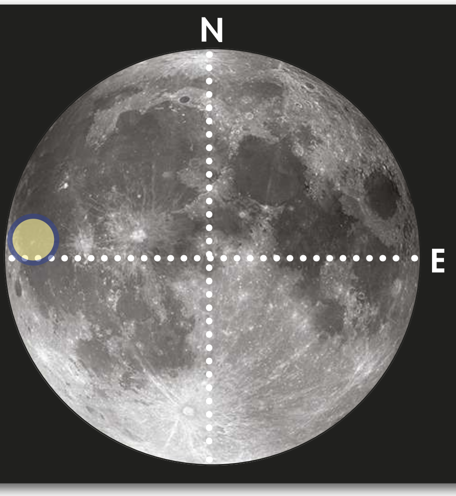
Ejecta rays tend to have no significant physical presence. Whereas an elevated or sunken lunar feature is revealed by the shadows it casts when the Sun is low in its sky, ejecta rays are made visible when the Sun is high up. Physical structures with height are described as relief features, while those that depend on the difference between their reflectivity to that of their surroundings, are described as albedo features.

The famous albedo feature Reiner Gamma lies to the west of the crater. It consists of a central 'eye-like' shape with two 'ribbons' of bright material emanating from either end. The least distinct ribbon heads south and west of the central eye, while the other traverses east before heading northeast. The ribbons are thin, and appear to swirl away from the central feature.

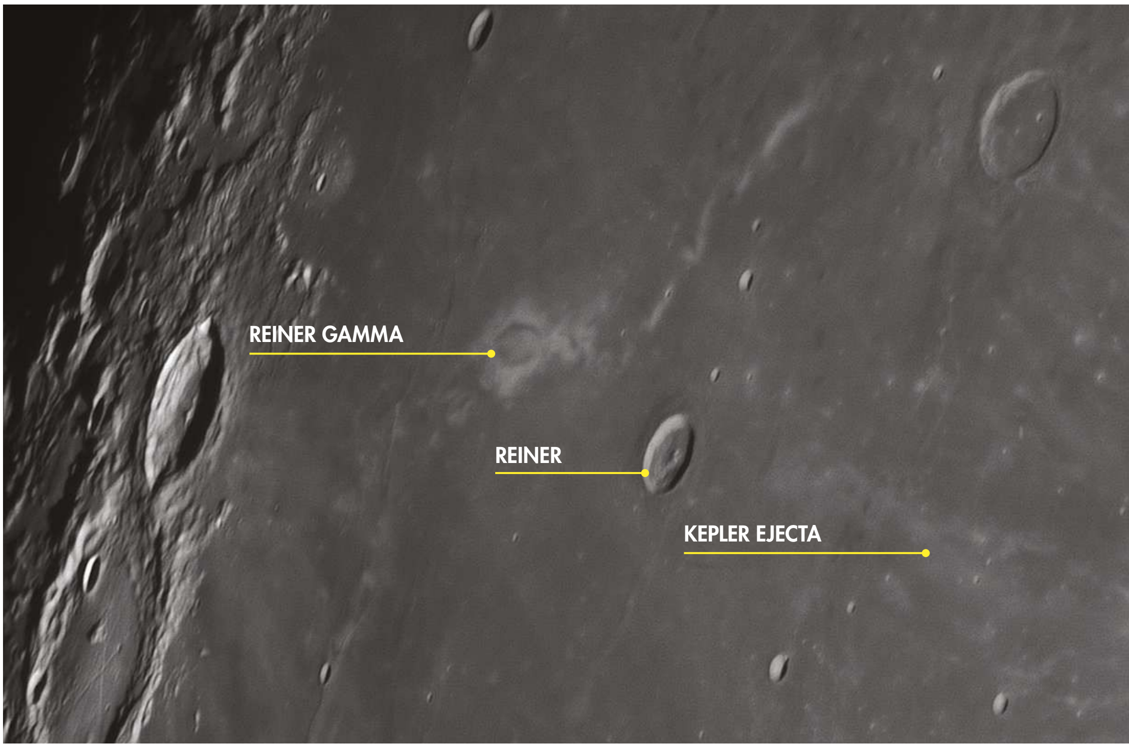
There are various explanations as to what caused Reiner Gamma. One is that it sits opposite a big impact on the lunar far side, and that the resulting shock waves passed through the Moon's bulk and focused on the area now marked by Reiner Gamma. When they reached the surface, material was kicked off the Moon. The area is known to have a number of magnetic anomalies and it's thought that the material that eventually fell back to the lunar surface was guided by the magnetic field here. As the material eventually settled it formed the bright eye and ribbons that we see today. Whether this theory is true or not, it's certainly compelling.

STATISTICS

TYPE: Crater
SIZE: 30km diameter
AGE: 1.1-3.2 billion years
LOCATION: Latitude 6.9°N, longitude 55.0°W
BEST TIME TO OBSERVE: Five days after first quarter or four days after last quarter (5 March and 20-21 March); Reiner Gamma is visible 1-4 March and 21-31 March
MINIMUM EQUIPMENT: 2-inch telescope



> **"The shadow looks like that you'd expect from a fairytale castle covered in spires"**



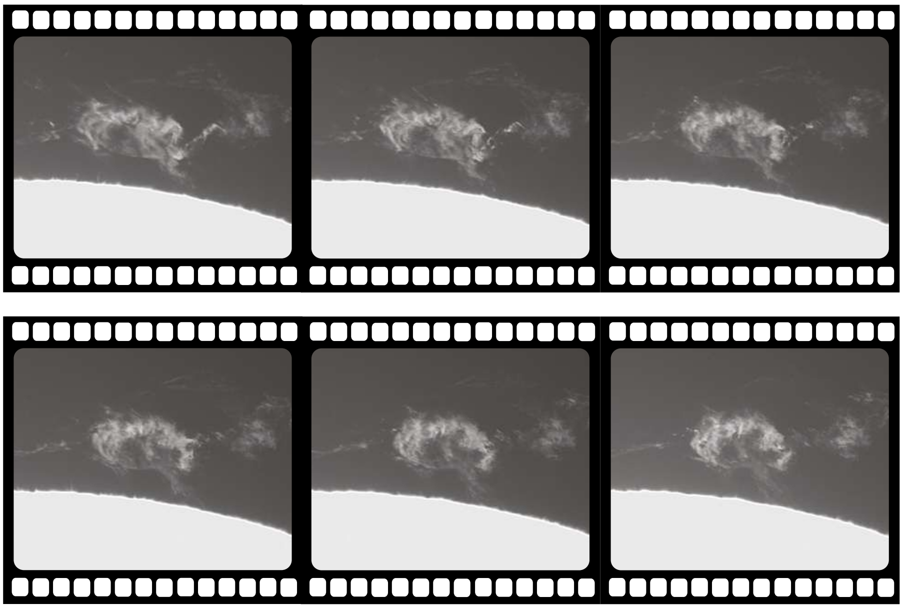
▲ The brightness of the Reiner Gamma albedo feature stands stark against the Oceanus Procellarum

Astrophotography

The dynamic Sun: prominences and filaments

RECOMMENDED EQUIPMENT

Solar telescope or scope with hydrogen-alpha filter, mono high frame rate camera



▲ Animating your captures will reveal the speed at which solar limb features can change

THE SUN IS a fairly unique astronomical object as far as we're concerned on planet Earth, being the body that delivers energy to our world. It's also rather special when observed. Here, all that life-giving energy has to be handled with respect and you should never point any instrument – and that includes your eyes – at the Sun without appropriate protection.

Observing the Sun in white light is relatively cheap and easy to do. The most common method is to purchase a sheet of solar safety film and make your own filter with the additions of some card and sticky tape. This will dim the view of the Sun's disc enough to allow you to look safely at the solar surface and take images of it.

This is a fascinating way to record the Sun's activity in its own right. Observing over the course of several days will show the development of any sunspot groups that are present, as well as revealing the Sun's, on average, 27-day rotation; the reason it is an average is that the figure varies by heliocentric latitude being shortest at the Sun's equator and longest at the poles. But this month, we're going to look at an alternative – hydrogen-alpha imaging.

A hydrogen-alpha filter is a speciality piece of kit that can be purchased in many different forms – from entire dedicated solar telescopes to filter kits which can adapt a night time scope for safe solar viewing. It's essential whatever kit you use, that you follow the manufacturer's instructions carefully. If you fail to do this, you may not only damage the filter and any equipment it's attached to, but possibly your vision as well.

A hydrogen-alpha filter will change your view of the Sun forever. Unlike its white light counterpart, where features change slowly over the course of many hours or days, hydrogen-alpha features can change over periods of a few hours, minutes or even, in extreme cases, seconds.

One of the most popular features to look out for is known as a prominence. This is an often huge magnetic 'sculpture' where cooler hydrogen plasma – a very hot form of matter – is held aloft by the Sun's contorted magnetic field. These clouds of hydrogen can take all manner of different shapes and sizes. From one day to the next, you'll never be entirely sure what you'll get to see.

Prominences can range in activity levels from quiet, hardly changing forms to extremely active ones that seem to lift off the Sun's limb. Hanging off the edge of the Sun, when viewed through an h-alpha filter, prominences glow of their own accord. However, as the Sun's rotation drags a prominence around the eastern limb, it eventually gets silhouetted against the hotter solar chromosphere below. Consequently, when this happens it looks darker than the chromosphere and is then known as a filament.

Their dynamic nature makes prominences and filaments ideal targets for imaging and animation. Pick the correct delay between images and the final flick-book style animation will really show the full power and beauty of these features. Such animations also give a fantastic insight into the way the Sun's magnetic field contorts and affects the plasma. As the days are now starting to get longer and the Sun climbing higher in the sky, this is a great time of year to get started with imaging our star in hydrogen-alpha.

KEY TECHNIQUE

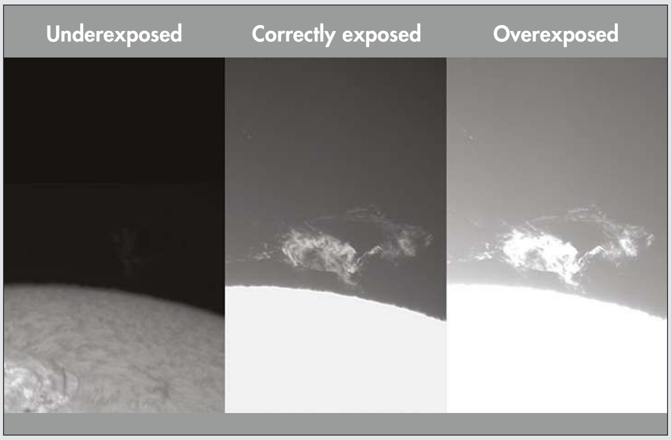
DAYTIME SEEING

Seeing affects the Sun just as it does any object in the night sky. Poor seeing is the result of turbulence in Earth's atmosphere. In the case of the Sun, our star's energy causes heat to radiate from any surface it falls on, and this heat affects seeing. The skill is in balancing the Sun's altitude against the turbulence its own energy is causing in the atmosphere: when the Sun is higher in the sky we see it through less atmosphere, but the heat of the day degrades the Sun's appearance when it's highest around noon.

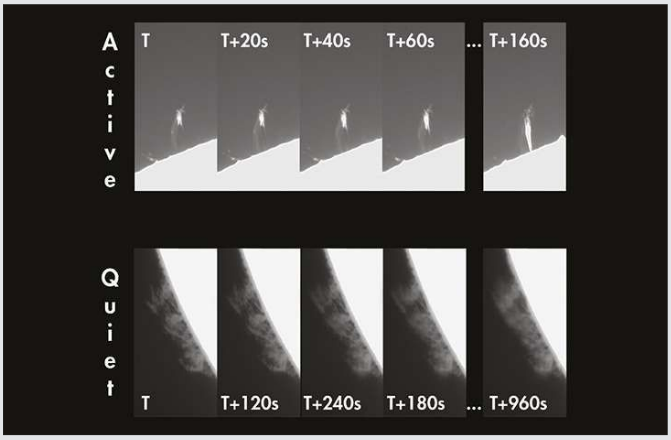
✉ **Send your image to: hotshots@skyatnightmagazine.com**

ALL PICTURES: PETE LAWRENCE

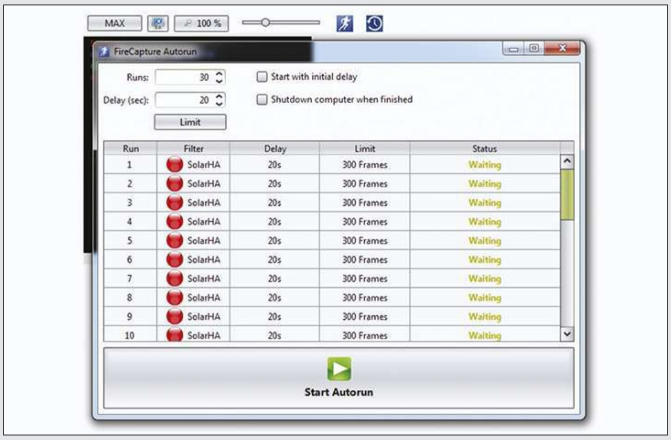
STEP-BY-STEP GUIDE



STEP 1 Make sure your hydrogen-alpha filter is tuned so that prominences appear as bright as possible. A high frame rate mono camera works best for prominence imaging. Set the gain to a mid or low value and adjust exposure to get a bright prominence with no white (overexposed) portions. Expect the solar disc to overexpose.



STEP 2 Capture time and the interval between captures depends on activity and magnification. For an active prominences at high power, capture time should be five to 20 seconds with a similar delay between captures. Aim for 200-300 frames. For less active ones at lower power, 20-second captures with an interval of 60-120 seconds should suffice.



Runs: 30

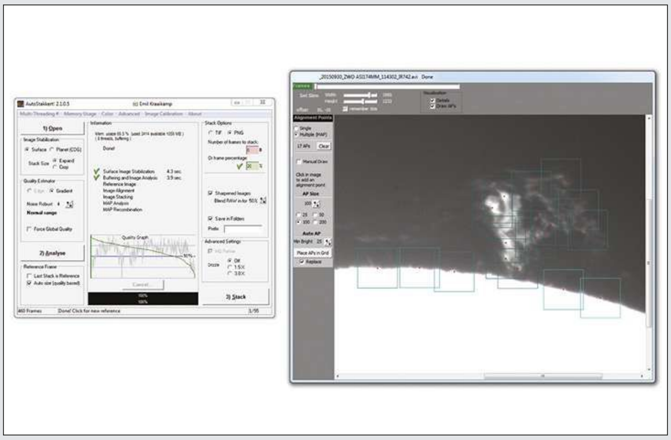
Delay (sec): 20

☐ Start with initial delay

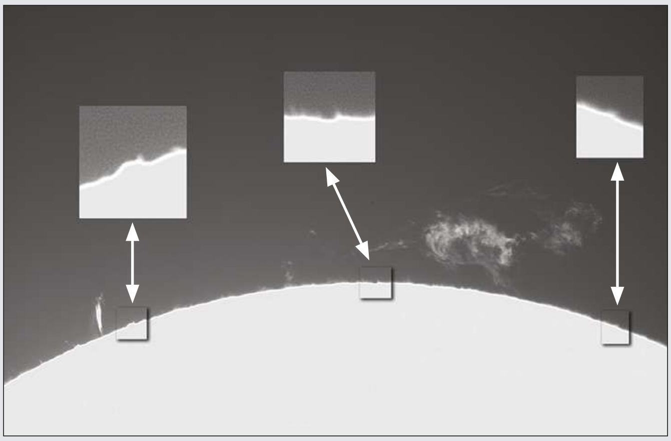
☐ Shutdown computer when finished

Run	Filter	Delay	Limit	Status
1	SolarHA	20s	300 Frames	Waiting
2	SolarHA	20s	300 Frames	Waiting
3	SolarHA	20s	300 Frames	Waiting
4	SolarHA	20s	300 Frames	Waiting
5	SolarHA	20s	300 Frames	Waiting
6	SolarHA	20s	300 Frames	Waiting
7	SolarHA	20s	300 Frames	Waiting
8	SolarHA	20s	300 Frames	Waiting
9	SolarHA	20s	300 Frames	Waiting
10	SolarHA	20s	300 Frames	Waiting

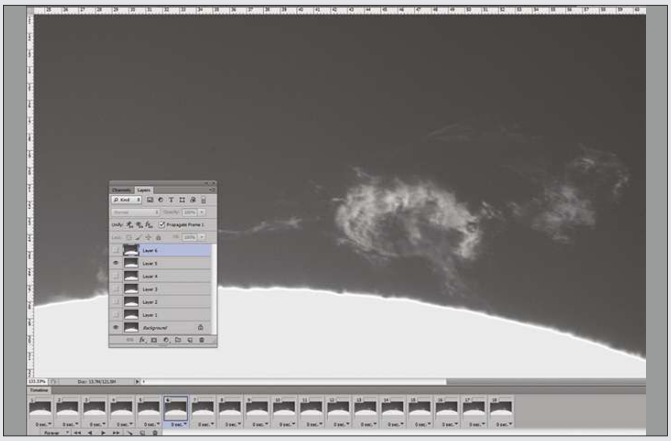
STEP 3 Many capture programs (including FireCapture, above) allow you to define the capture time, interval and number of captures. If yours does not, you can perform the captures manually. If your software gives you an on screen reticle, use that to help keep a more static feature, possibly a bump on the limb, in the same position throughout.



STEP 4 Batch process results in AutoStakkert!: drag your captures into the main window, select Surface, then ctrl-click on a high contrast feature and click Analyse. Set Stack Options percentage to 20, AP size to 100 and click over high contrast features on preview to set alignment points. Click Stack and load the results as layers in Photoshop.



STEP 5 Make all layers except bottom two (Background and Layer 1) invisible. Align Layer 1's position with the background. Toggling visibility helps if you used a bump on the limb for reference. These do change over time but work between frame pairs. Repeat for next layer up, aligning to layer below. Finally, crop off any rough edges created when aligning.



STEP 6 For the animation, select Window > Timeline (or Animation). With only the background layer visible, duplicate timeline frame so the frame count matches number of layers. Make Layer 1 visible in second timeline frame, Layer 2 in third frame and so on. Click the play icon to check the animation. To save the animation as a GIF, select Save > Save For Web.

The future of Patrick's home in Selsey was the subject of much speculation – many hoped it would become a museum

▲ Patrick Moore's iconic monocle went up for auction at Christie's in South Kensington, eventually selling for £688

► Various smaller items went under the hammer at Henry Adams, including the Remington typewriter that Patrick used through his life

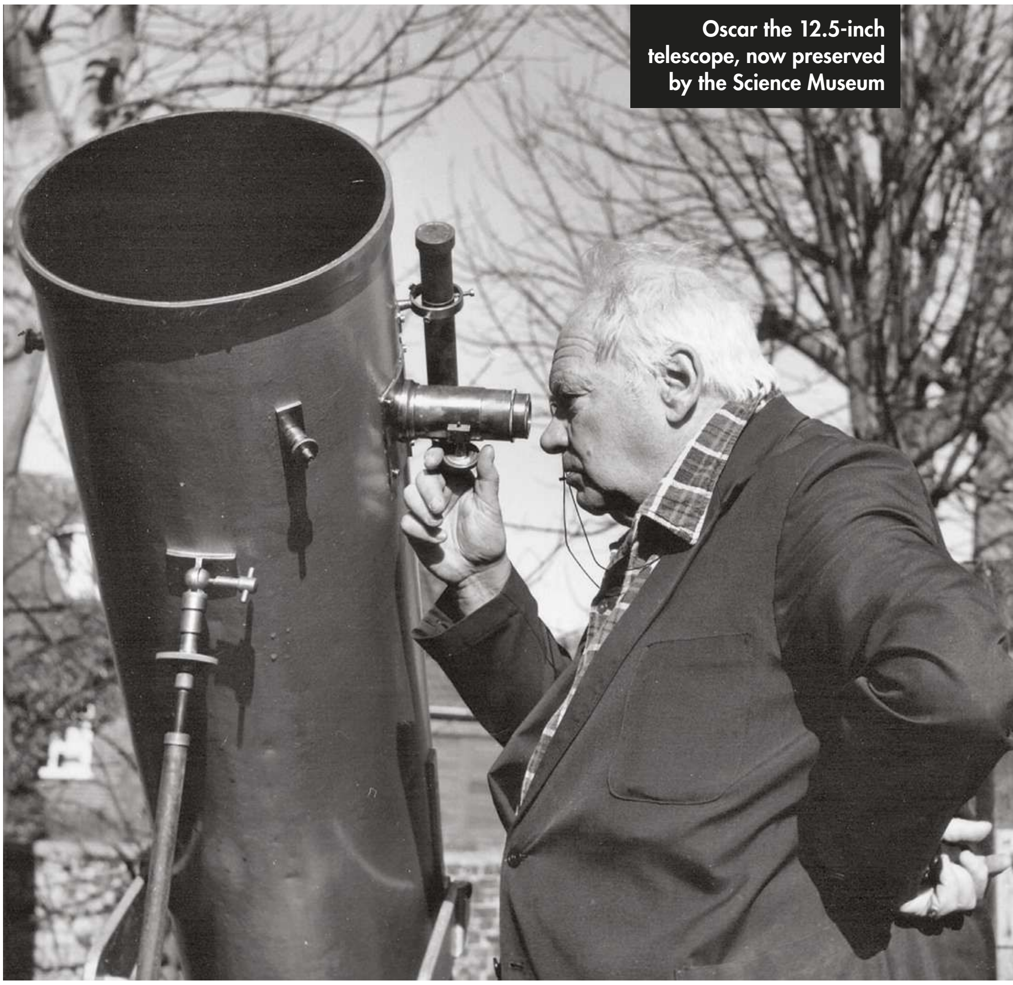
The fate of FARTHINGS

How do you preserve the work of Britain's favourite astronomer? **Iain Todd** seeks out the story behind Patrick Moore's estate

When Sir Patrick Moore passed away in December of 2012, the world lost one of its most famous and celebrated astronomers. Speculation quickly arose as to whether his home, Farthings in Selsey, might be made into a museum but planning considerations eventually ruled this out. According to Patrick's close friend, rockstar-turned-astrophysicist Dr Brian May, the house is to be sold, with the proceeds going to the South Downs Planetarium in Chichester, of which Patrick was a patron.

But what about the contents of the house? Patrick's possessions included a multitude of astronomical equipment, telescopes, globes, notebooks and scrapbooks, as well as souvenirs and knickknacks picked up on his travels. His collection of shot glasses alone stretched into the hundreds.

Patrick never married, nor did he have any children or close relatives to whom he could bequeath his worldly goods. But before he passed away, he appointed executors to oversee the distribution of his estate, including May and astronomer Dr John Mason, who helped found South Downs Planetarium. It fell to them to decide how best to preserve Patrick's legacy.


Oscar the 12.5-inch telescope, now preserved by the Science Museum

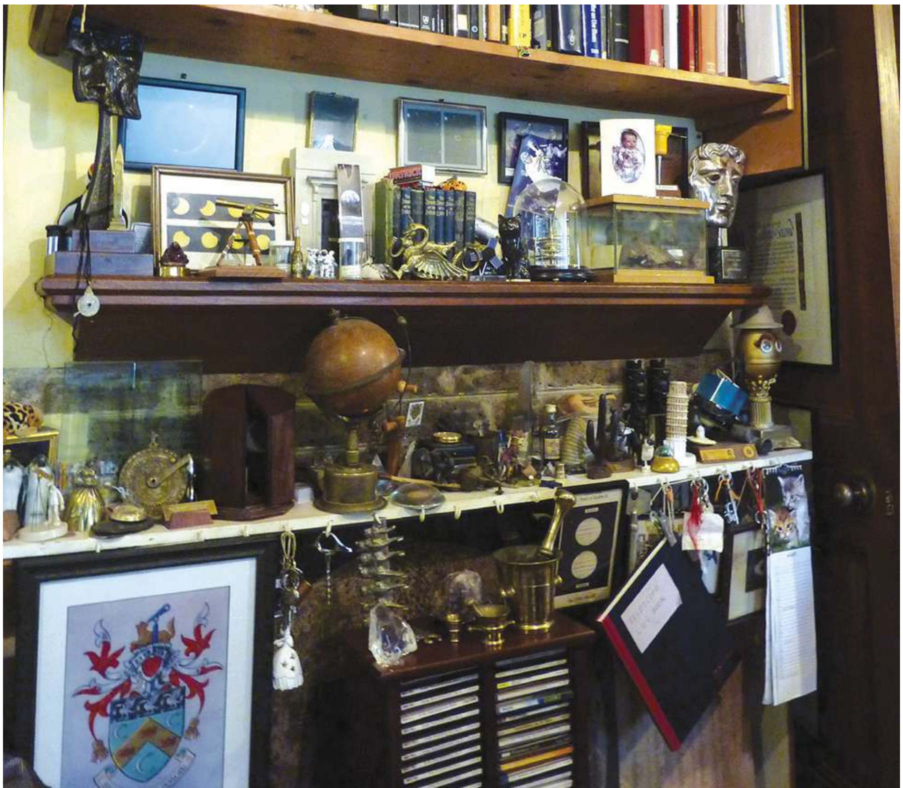
Saved for the nation

They worked with the Science Museum to take the majority of the collection, which is now held at its archive in Wroughton, where it will be accessible to the public.

"We initially thought it would be great to acquire the whole collection, but it became apparent that the scale of the collection wasn't going to enable us to do that," says Alison Boyle, curator at the museum. "We were keen to not just capture the public face of Patrick Moore as a populariser of astronomy, but also his work as an astronomer. One of the most intriguing items was a 12.5-inch telescope named Oscar, which he used for his lunar mapping work. Oscar required a good deal of care and attention from our conservation team and was one of the items that most intrigued us."

The Science Museum also acquired Patrick's notebooks, of which there are about 70, including some 60 years of drawings, observations and a collection of astronomy-related newspaper clippings spanning decades. Patrick also kept old draft scripts from his work on *The Sky at Night*, complete with notes detailing how episodes were developed during filming. These too are now safe in the museum's archives.

"We are cataloguing each item so any future researchers can make sense of it," says Boyle. "We're starting on the areas that are quicker to catalogue, which are the photographs and a collection of medals. The papers take a bit longer due to the sheer volume of them, but we are working our way through those and will eventually get them on our new online catalogue. We have just opened a new research centre at our site in London, so ▸


◂ Patrick's study was representative of the rest of his house, crammed with objects he had collected throughout his life

ISTOCK, CHRIS BALCOMBE/REX SHUTTERSTOCK, © CHRISTIE'S IMAGES LTD 2015, HENRY ADAMS X 5, COURTESY OF THE TRUSTEES OF THE SIR PATRICK MOORE HERITAGE TRUST, © CHRIS DOHERTY

▸ people will be able to contact the library there to view material."

There are currently no plans for a permanent exhibition, but some items could feature in the museum's space and astronomy displays. In fact, one of Patrick's lunar globes features in the Cosmonauts exhibition, which runs until 13 March.

"Patrick had a lot of lunar globes," says Dr John Mason. "We made sure that all of the ones that were of interest went to the Science Museum, including the Russian globes from the late 1950s and early 60s that resulted from the Moon mapping done by Russian probes. Patrick was in contact with the Russians and Americans in the late 1950s and, having no political axe to grind, was seen as an impartial expert on lunar structures, features and geology, particularly the libration regions. This enabled the Russians to tie in the imagery of the lunar near side with the new imagery being obtained of the lunar far side."

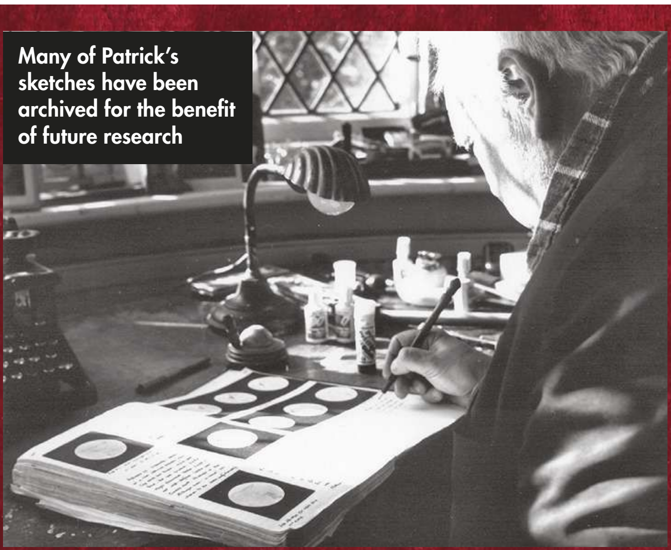
The Russian lunar globes from the 1950s and 60s are among the artefacts acquired by the Science Museum

Under the hammer

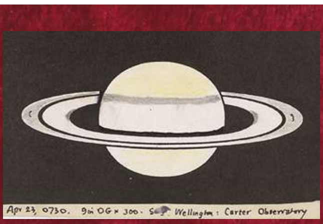
The items that could not be taken by the Science Museum were sold at auction by Christie's in London's South Kensington and Henry Adams Auctioneers in Chichester, near Patrick's home, both at the beginning of October last year. Proceeds from the two sales are destined for the Sir Patrick Moore Heritage Trust, a charity set up to promote Patrick's legacy.

We paid a visit to Christie's on the day of the auction. Enthusiasm was palpable, the auction room slowly filling throughout the morning as Patrick's lots drew nearer. Online bidders from around the world were in virtual attendance, with one item creating a stand-off between bidders in Texas and California – proof, as if it were

© ROGER BAMBER/ALAMY STOCK PHOTO, COURTESY OF THE TRUSTEES OF THE SIR PATRICK MOORE HERITAGE TRUST X 3, ISTOCK, © CHRIS DOHERTY, PATRICK MOORE X 3, HENRY ADAMS X 6



Many of Patrick's sketches have been archived for the benefit of future research



Apr 23, 0730. 9in OG × 300. S Wellington : Carter Observatory

▲ South Downs Planetarium has acquired three of Patrick's beloved telescopes, including the 3-inch refractor he bought himself in 1933

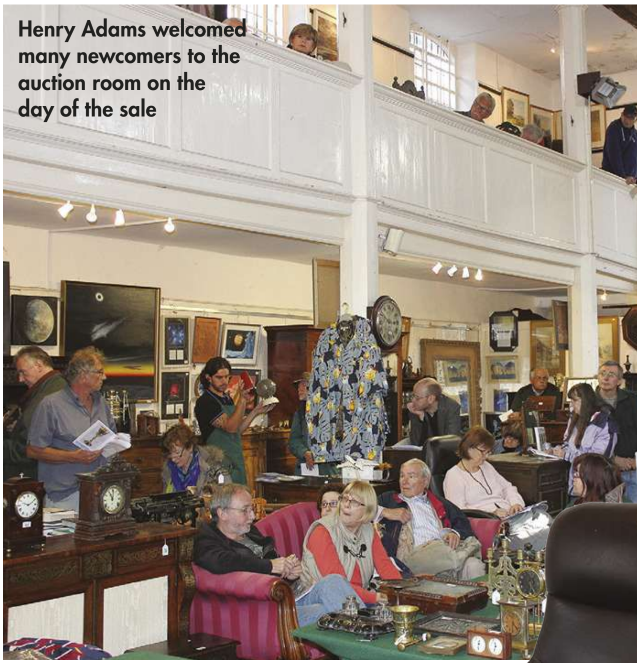
THE SCIENCE BEHIND **PATRICK'S LEGACY**

Dr John Mason of South Downs Planetarium discusses the scientific value of Patrick's estate

"Patrick's notebooks will be of major historical interest to people looking at developments in astronomy throughout the decades. His work on the Moon, for example, began in the early 1950s at the Meudon Observatory in Paris, using their 33-inch refractor. We have mapped the Moon in greater detail now, but in terms of putting into perspective how important it was at the time, those observations are of great interest.

Patrick's observations span such a long period and will enable people to see how he observed, for example, the dust storms on Mars in 1971 and 1973, the South Tropical Disturbance on Jupiter or the ring plane crossings of Saturn. All these are shown in his notebooks and are now being preserved in the Science Museum.

His collection of newspaper clippings is equally invaluable. I doubt there is such an archive anywhere else of astronomy news going back so far. For a scientific historian or even someone looking at how astronomy was viewed in the media, this will be an immensely useful resource. We also have three of Patrick's telescopes. The 3-inch refractor he bought in 1933 is currently on display at the South Downs Planetarium, while the other two telescopes, a 5-inch refractor and a 15.5 inch fork mounted reflector, have been dismantled and will be re-erected to inspire the next generation of young astronomers."



Henry Adams welcomed many newcomers to the auction room on the day of the sale

◂ Memento boxes captured the essence of Patrick's passions and personality

▴ Patrick's xylophone was a big hit on the day, eventually going for £1,500

◂ Even everyday items were auctioned purely because they were linked to Patrick

▴ Works of art auctioned by Henry Adams: left is a photo of the Comet Hale-Bopp taken by Patrick, while right is a portrait by T Tyler

needed, that Patrick's influence was international.

"There was such a wonderful range, especially some of the globes," says James Hyslop, head of department for science and books at Christie's South Kensington, who oversaw the handling of the items. "They weren't necessarily some of the most expensive globes that we've ever handled, but they were so iconic, having been in the background of *The Sky At Night* for the last several decades.

"There were some extremely rare items, like a 19th Century globe of Mars of which there are really only a handful known. I had certainly never seen a globe of Mars by this maker before, and it was very exciting to see some of the rarities really capture collectors' imaginations."

Henry Adams Auctioneers handled the remainder of the estate, comprising mainly the smaller items, but also some larger pieces like one of Patrick's xylophones. Being so close to Patrick's home in Selsey, the auction drew quite a crowd.

"It was a very busy day: there were lots of people so the saleroom was full," says Andrew Swain of Henry Adams, who oversaw the auction. "Many people were completely new to auctions, so there was a lot of explaining as to exactly how the whole process works."

Because Henry Adams was tasked with auctioning the smaller items, Swain came up with the idea of creating memento boxes, each including a Hawaiian shirt, a pipe, a tie, a Pewter mug, a paperweight, four shot glasses and a letter opener. These were some of the most popular items to go under the hammer on the day. But, Swain says, most interesting was the buzz throughout the busy auction room, as bidders shared anecdotes and stories of Patrick from down through the years.

"So many people had stories of the help with astronomy Patrick had given them," he says. "He always had the time of day for everyone, and I think that's why people liked him."

A unique legacy

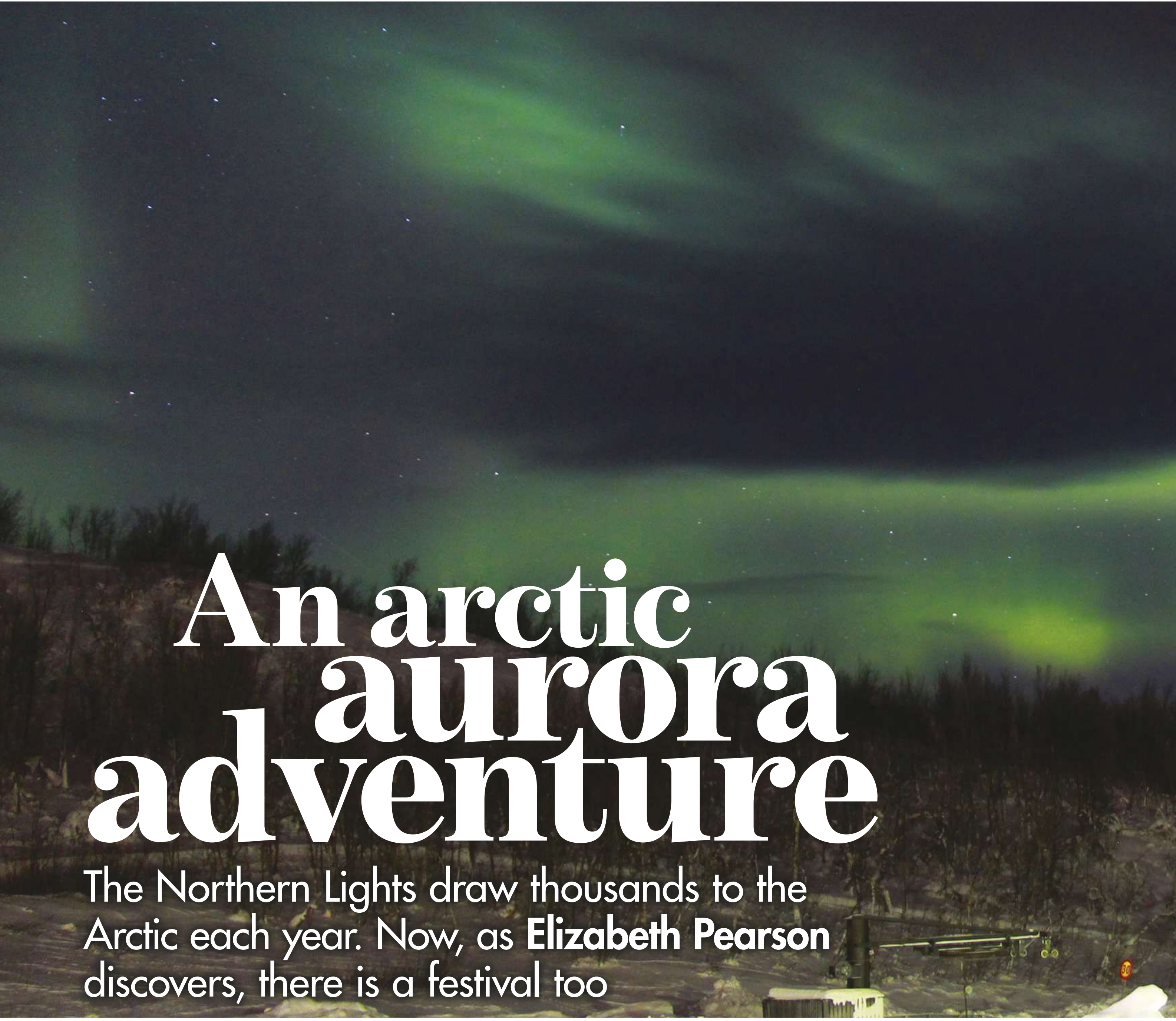
It seems Patrick's passing and the subsequent handing of his estate have been a source of remembrance for many people who met and knew him through the years, while others have been able to gain insight into the generous and warm character for which he was famed. Patrick's long-term legacy, however, is in the work of the Heritage Trust and the many items preserved in the Science Museum that will serve astronomers and scientists alike for generations to come.

"There aren't many people whose items we would acquire with the enormous recognition that Patrick Moore has, but because he had such a long life and career, this collection will be a brilliant resource," says Boyle.

"Our hope is that it will be widely used. The point of us acquiring archives like these is that people will come and work on them and that other museums can use and borrow them. We are sure it will be a great resource for future generations." Ⓢ

ABOUT THE WRITER

Iain Todd is *BBC Sky at Night Magazine*'s editorial assistant. He has been a journalist, writer and researcher for 10 years.



An arctic aurora adventure

The Northern Lights draw thousands to the Arctic each year. Now, as **Elizabeth Pearson** discovers, there is a festival too

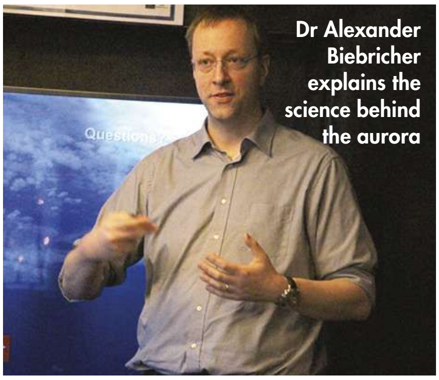
For hundreds of kilometres all around there is little more than snow and ice. It's quiet, with only the crackling of the fire breaking the silence. Nearby, a group of people sit in the cold, waiting for lights to appear in the sky.

This was the landscape that surrounded the first Aurora Festival in Björkliden in northern Sweden in January 2016. By day an informative programme of expert talks uncovered the science of the aurora – how it's sparked by particles from the solar wind – while over its two nights the attendees headed out to hunt for the Northern Lights.

The first thing we needed to begin the hunt were the right tools. We had our cameras, now we needed to learn how to predict the aurora. We downloaded free magnetometer apps onto our phones and tablets (try AndroSensor for Android and Magnetometer for iOS), which let us measure the local field. While local magnetic field strength has little relation to the field higher in the atmosphere that governs the aurora, it did give us a visual feel of the force that turns the potentially fatal solar wind into a beautiful natural phenomenon.

To predict the Northern Lights, you need to use one of the many satellites measuring the field high above the Earth. While free apps like Aurora Forecast (iOS and Android) and Northern Eye Aurora Forecast (Android) keep an eye on the strength and density of the incoming solar wind, the magnetic field is often overlooked – despite being as important in terms of whether a display will occur. Even if a colossal solar storm were to hit directly overhead, if the magnetic field isn't aligned correctly then there will be no aurora.

Luckily for us, space weather seemed to be on our side and that night aurorae looked likely. Unfortunately the terrestrial forecast wasn't so co-operative. As the sky turned once more to true dark, the clouds rolled in.



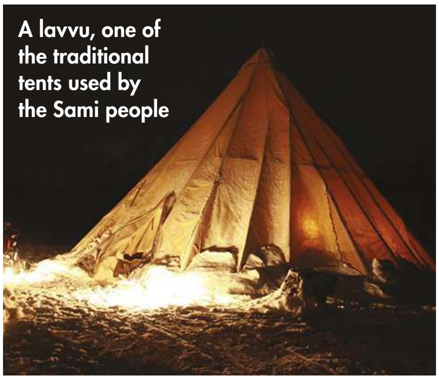
Dr Alexander Biebricher explains the science behind the aurora

Into the wilderness

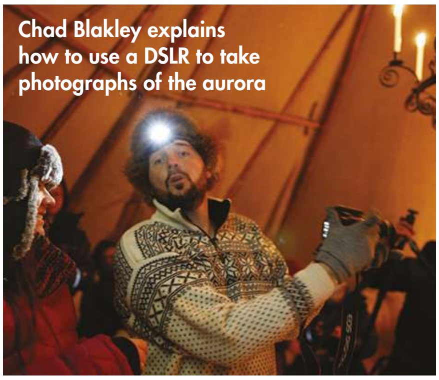
Hopeful of a break in the clouds, we walked a few minutes away from the hotel to get away from the streetlights. Up on the top of the mountain was a traditional lavvu, a circular tent similar

ELIZABETH PEARSON X 5, FREDRIK BROWMAN

Thankully the Northern Lights made a spectacular showing at the festival



A lavvu, one of the traditional tents used by the Sami people



Chad Blakley explains how to use a DSLR to take photographs of the aurora

▲ **Elizabeth uses her phone to examine the local magnetic fields**

to a teepee used by the Sami, the region's indigenous people. Inside Chad Blakley, local expert in aurora photography, taught us how to make sure we made the best of our aurora photographs.

However, no amount of skill in photography can make the clouds disappear. Feeling dejected, we gave up hope of seeing the lights that night, and headed back to the bar. But just as we were about to head to bed, word came in that the Lights were up. Grabbing our cameras we rushed outside and there, straight out of the door, a band of green crossed the sky – the aurora we had all come to see.

Trying to remember the talk earlier, we fired off as many shots as we could, trying to find the perfect alignment of foreground and the aurora, trying different exposure lengths to bring out the display to best effect. Then I remembered something else I'd been told earlier by Frederick Broman, an aurora photographer who grew up in the region.

"It's quite relieving to just enjoy the aurora without the camera. A couple of ▸

The aurora began as a single band of green across the sky...

▸ years ago it was hard for me. If there was an aurora I needed to take pictures. Sometimes now I actually don't go and run for the camera. I just enjoy it."

Stepping back from the camera I watched enchanted as the lights changed above me. At first a broad band grew and waned, finally collapsing down into a thin line that broke apart to form great pillars of light across the sky.

The real thing looks very different to what you see in pictures, and not just because they do not capture the aurora's wafting movement. To me the lights seemed only a pale green, but others saw it as luminous, and some didn't see any colours at all. Just as every aurora is different, everyone sees it in slightly different way. For those who had never seen the lights before, the experience was very moving.

"A few nights ago I was with a father and daughter," says Blakley. "The lights were so magic that she started to break down into tears and, seeing her, the father started crying too. These two were otherwise composed and professional, but they were brought to tears by something that is 100 per cent natural. It is such a magic thing."

Even when you have seen them before, finding the aurora is always a thrill. It's

HOW TO CAPTURE **THE AURORA**

Once you've found the aurora, taking photographs is relatively straightforward

The first stage to capturing the aurora is predicting when they will appear. There are many apps to help, but it is also useful to check the magnetic field direction. The real-time graph available online on the Space Weather Prediction Centre website (www.swpc.noaa.gov/products/ace-real-time-solar-wind) tracks the weather at the L1 point, 1.5 million km from Earth.

"This gives you around an hour before it reaches Earth," says space physicist Dr Alexander Biebricher. "The red line signifies the magnetic field. If that red line is below 0 and stays there for half an hour, then you are likely to have a show."

If space and Earth weather cooperate the next thing to do is get your camera set up. Most DSLRs should be up to the task. The ISO should be at least 1600. The aperture should be as large as possible. Most standard lenses will go down to f/3.5, but if you have a larger aperture, so much the better.

To prevent blurry stars, focus your camera to infinity. Do this by zooming in on a distant light – in my case the lights of the town below – and manually bring it into focus.

Because of the low light, you'll need a long exposure, which means you'll need a tripod. If you have a remote shutter, that will help to reduce camera shake. Exposure length should be between 10 and 30 seconds, depending on the effect you want: longer ones bring out colours, and shorter ones capture detail.

▲ Chad Blakley hosting a class on how to get most out of your camera under the aurora

▲ Putting that advice to good use led to this 30-second exposure of the aurora

...and soon broke off into pillars and waves, moving slowly across the night

even more so when you know the remarkable science behind them, how the charged particles responsible for the Lights overhead came from our star, some 150 million km away, and are now being channelled along field lines that were created in the core of our planet.

Envoy from the Sun

"The aurora has its origin in the Sun, which sends charged particles like electrons and ions out into space, which may then enter the Earth's atmosphere," says space physicist Dr Alexander Biebricher of the Norwegian Centre for Space-Related Education. "When these particles collide with molecules in Earth's atmosphere, especially oxygen and nitrogen, the molecules become energised and give off light. Oxygen gives off green and red light, the main colours of the aurora."

The experience was made all the sweeter for the uncertainty in whether or not we'd ever get to see the aurora. Luckily, in this part of the world the hunt isn't that troublesome (beyond getting to an arctic town in remote north Sweden) as the region benefits from a unique climate.

"Weather is the biggest obstacle when it comes to seeing aurora," says festival organiser Johnny Cooper. "In Björkliden and Abisko we sit in the 'rain shadow' [of the mountains] so we get a higher percentage of clearer nights, and that is obviously critical when it comes to seeing the aurora."

But a track record for clear weather is no guarantee, and this would be the only auroral display we would get to see that trip. There was plenty else to occupy us, as we learned about the culture and history behind the Northern Lights. Many northern peoples have a strong connection with the aurora, some cultures seeing them as good omens, others as ill. The Sami people associate the aurora with the dead and believe it is disrespectful to whistle at them. For local Swedes however, the newfound interest in the aurora from tourists has helped them to reconnect with the mysterious lights.

"The local relation with the aurora had been lost for a while, but with so many people coming to see them, it brings a new perspective," says Broman. "It changes how we view the aurora: we search for the aurora ourselves now – we appreciate them more."

There is certainly a magic to the aurora. Before I even got home I was thinking about going back to northern latitudes in the hope of catching an even better display.

"You always want to see something that's brighter, or faster, or has more colours," says Cooper. "It's addictive."

Every year thousands of people get the bug, but the allure of the aurora is hard to pinpoint. Is it their beauty, their mystery or their transience that captures people's minds? "People travel all over the world to see natural beauty on Earth," says Blakley. "The aurora is the only thing that you can witness that's beyond our shores, at the edge of our atmosphere. You're not looking at something that's known, you're quite literally witnessing weather occurring in space. That's a pretty fantastic thing."

▶ **Elizabeth travelled to Björkliden with Off The Map Travel**

ABOUT THE WRITER

Dr Elizabeth Pearson is *BBC Sky at Night Magazine*'s news editor. She gained her PhD in extragalactic astronomy at Cardiff University.

WHERE TO SEE THE NORTHERN LIGHTS

Despite the Arctic climate, you can look for aurorae in comfort across Scandinavia

AURORA FESTIVAL

Operator Off The Map Travel
Location Björkliden, Sweden
Price £975 (excluding flights)
www.offthemaptravel.co.uk

The three-day, two-night festival included talks from world-class experts in the science and pursuit of the Northern Lights.

LIGHTS AT THE LODGE

Operator Visit Narvik
Location Narvik, Norway
Price 1,395 NOK (~£110)
www.visitnarvik.com

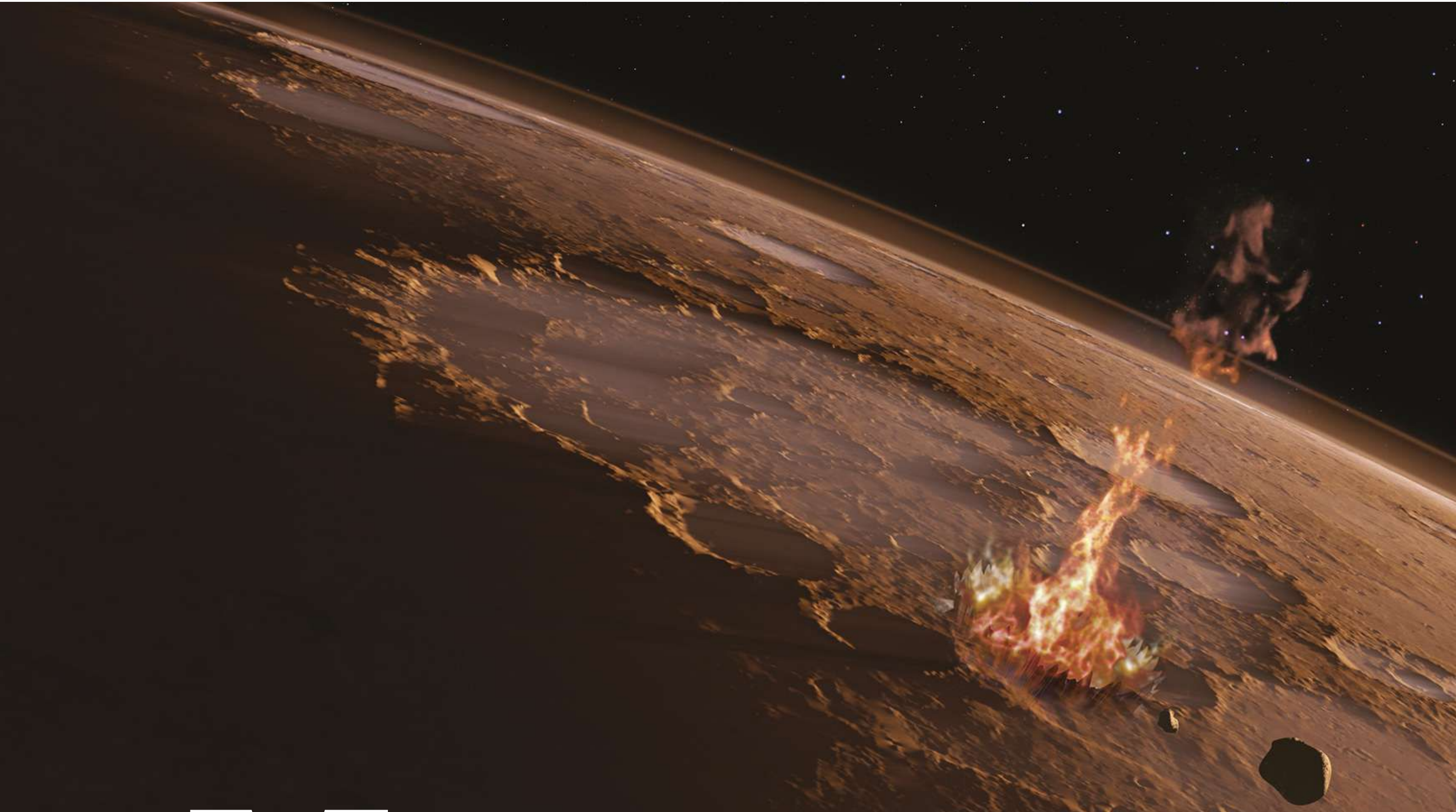
Take a gondola to the top of the mountain to watch the Northern Lights above the city from the comfort of a lodge.

KAKSLAUTTANEN ARCTIC RESORT

Operator Discover the World
Location Kekkonen National Park, Finland
Price From £1,248 for three nights
www.discover-the-world.co.uk

Watch the northern lights from your bed in one of the glass domed 'igloos' or stay cozy in a traditional one.

ELIZABETH PEARSON X 4, OFF THE MAP TRAVEL, FREDRIK BROWMAN, JAN ARNE PETTERSEN



Messengers from the Solar System

There are samples of planets and other Solar System objects already here on Earth. **Will Gater** speaks to the scientists lucky enough to be working with them

If there's one thing that defines of Solar System science today, it's the scattering of robotic explorers we've sent out among the planets. Our emissaries have journeyed to to cratered asteroids, tumbling comets, the ochre plains of the Red Planet and many more besides.

Each probe and lander has been a proxy for the geologist's hand, reaching out toward an unknown world, or the scientist's eyes, contemplating an unexplored vista. Look at any spacecraft being assembled in a cleanroom and what you see in the instruments and cameras screwed to its frame is its earthbound science team's spirit of enquiry and curiosity brought into physical form.

At Mars today, NASA's Curiosity rover is exploring the dunes and outcrops of Gale Crater. Its more formal title – the Mars Science Laboratory – is a hint of the impressive range of scientific tools it's using on the Red Planet. And when ESA went to visit comet 69/P Churyumov-Gerasimenko with the Rosetta mission they sent a lander too, Philae, crammed with advanced instruments for studying the icy surface.

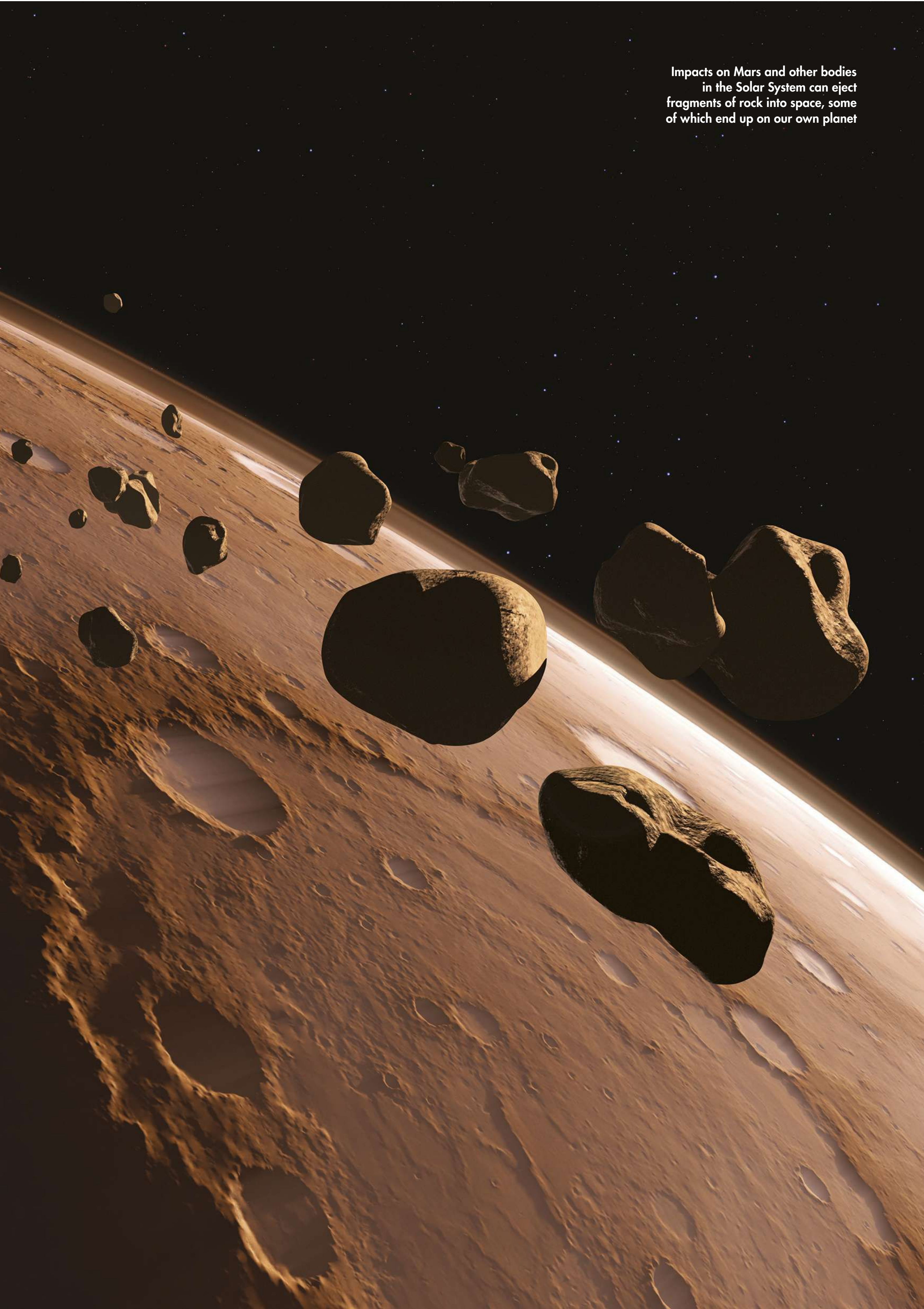
Delivering these miniature laboratories to their targets presented enormous technological challenges, but the potential rewards are immense. Being able to analyse the rocks, dust and soil of our planetary neighbours up close can help researchers answer some of the biggest questions in science today. Yet while these missions grab headlines around the world, few realise that there are already precious pieces of a select few Solar System bodies being scrutinised in laboratories right here on Earth.

Some of these rare samples we've collected ourselves on daring missions; some arrived ▸

ABOUT THE WRITER

Will Gater is an astronomy journalist, author and astrophotographer. Follow him on Twitter: @willgater

DETLEV VAN RAVENSWAAY/SCIENCE PHOTO LIBRARY, ISTOCK X 2



Impacts on Mars and other bodies in the Solar System can eject fragments of rock into space, some of which end up on our own planet

▲ **Curiosity is doing great research on the barren plains of Mars, but its samples remain sadly beyond our reach**

▸ on their own by sheer chance. What they all have in common is that their stories are just as compelling as those garnered from spacecraft spread across the Solar System.

As close as a rover

Dr Katherine Joy, from the University of Manchester, had been interested in space from a young age, but it was her PhD in lunar science – which involved looking at data from ESA's SMART-1 spacecraft – that led to her studying our nearest neighbour. "I watched the mission launch successfully a week before my PhD was due to start," she recalls today. "As it was testing out a novel ion engine we had 18 months to wait until the mission crawled to the Moon, so I spent a long time learning how to study Moon rocks to help interpret the spacecraft data."

Nowadays Joy's research gets her just as close to the Moon as SMART-1 was, as she is one of several UK scientists analysing pieces of the lunar surface in the lab. Some of these samples are lunar meteorites – fragments of rocky shrapnel that have made the fiery passage through our atmosphere and landed on Earth after being blasted from the Moon by asteroid impacts. Over 230 of these lunar treasures have been discovered sitting on terra firma so far, with a number of them having been picked up during dedicated meteorite hunting expeditions to Antarctica by the US Antarctic Search for Meteorites (ANSMET). There the vast, white expanses offer a prime searching ground for these dark pieces of extraterrestrial rock.

▼ **Two members of the ANSMET 2012-2013 team collect a meteorite sample, its dark colour obviously out of place in the Antarctic snow**

"Once collected these samples are carefully curated at the Johnson Space Center in Houston, and are loaned out to scientists for study all over the world," says Joy, who herself has been on two ANSMET expeditions. Meteorites of lunar origin have also been uncovered resting on the sands of sweltering deserts such as the Kalahari and Sahara, she says. "These samples are often sold on the open market as a commodity, although many are located in museums around the world and are kept for research or public display."

To really be sure that the rock they have in their lab is actually from the Moon, researchers have to look at its interior composition. "We typically have to cut the samples open, take a careful look at the types of minerals present and determine what the chemistry of these minerals is, to investigate if they are similar to the Apollo samples," explains Joy.

"We can also isotopically fingerprint the samples – most planetary bodies have distinguishing signatures in terms of elements like oxygen. For some samples it takes several lines of evidence to tie it to a particular planetary body."

With the provenance of the sample confirmed, Joy can then focus on seeing what secrets it has to reveal. A typical analysis might involve studying the sample's structure and composition with powerful microscopes, as well as having it dated.

"We can try and ask where that sample may have come from on the lunar surface," says Joy. "We can compare the bulk chemistry of the sample to chemistry data sets of the lunar surface collected by remotely

NASA/JPL-CALTECH , ANTARCTIC SEARCH FOR METEORITES PROGRAM/KATHERINE JOY, NASA X 3, © THE NATURAL HISTORY MUSEUM/ALAMY STOCK PHOTO

▲ **Apollo astronauts returned 382kg of lunar rocks, pebbles, dust and core samples; this specimen was picked up during Apollo 12 in 1969**

orbiting spacecraft. This link is important to try and tie what information we have learnt from the sample to the big picture geology of the Moon." It's that 'big picture' view that makes these studies of lunar meteorites so valuable.

The Moon as a tool

"The Moon has been Earth's sister planet throughout its history and we can use it to understand fundamental planetary processes, from planet formation to crustal formation processes, to how planets are modified by volcanism and tectonism," argues Joy. "The Moon also provides us with a natural archive of Solar System processes – we can find out when it was struck by impacting projectiles such as asteroids and comets."

Joy doesn't just have to rely on meteorites to piece together our natural satellite's tale, however. She is one of a number of scientists across the UK that have access to arguably the most famous Moon rocks in the world – those lugged back to Earth by the Apollo astronauts. "Many of us are using both traditional geoscience techniques and state-of-the-art analytical instrumentation to reanalyse well studied [Apollo] samples to make new discoveries, and also to investigate material that no one has ever looked at before," she says.

Joy's own research has focused on examining material returned by Apollo 12 and Apollo 16 – in the case of the latter using advanced microscopes and other instruments to study a type of rock known as a 'regolith breccia'. "These are samples of ancient lunar soil that were fused together to make complex mixtures of many different rock types," explains Joy. "I was able to locate very small fragments of meteorites that had been delivered by impacting asteroids, which gave us insights to the bombardment history of the Moon through time."

With the Apollo samples still providing such a rich vein of selenological intel decades after they ▸

SPECIAL DELIVERIES

Three principal avenues bring samples from elsewhere in the Solar System to Earth

FALLING TO EARTH AS METEORITES

Spot a meteor on a clear night and what you're seeing is the result of a fleck of space dust vaporising as it hits our atmosphere at high speed. But sometimes sufficiently large and sturdy chunks of Solar System debris survive this fiery experience and make it to Earth's surface. These are meteorites, and they have been blasted from various asteroids, the Moon and even Mars. All of them can be searched for, collected and studied to give insights into the bodies they originated on.

APOLLO MISSION MOON ROCKS

The US missions to the Moon during the 1960s and 70s are widely regarded as the pinnacle of human exploration and ingenuity. And while the desire to land on the Moon was undoubtedly politically motivated, the Apollo programme nonetheless had an important scientific legacy: the astronauts that walked on the Moon brought home over 380kg of lunar rocks and soil. This material is stored at the Johnson Space Center in Houston and provides insights into the geology of the Moon to this day.

SAMPLE-RETURN SPACECRAFT

Of the many robotic missions we've sent out among the planets, only a small handful have involved a sample-return element. For example, NASA's Stardust mission arrived at comet Wild-2 in 2004 and captured dust released from the comet with a special collector. That collector was then stowed in a capsule before being delivered to Earth in 2006. And in 2005 the Japanese mission Hayabusa visited asteroid Itokawa, where it gathered a small amount of surface material before returning it to Earth.

▸ were brought to Earth, it's not hard to see why planetary scientists are so keen to launch sample-return missions to other bodies in the Solar System. Perhaps the most famous example in recent years is NASA's Stardust mission, which brought back flecks of dust from comet Wild-2 in 2006 using a special aerogel collector and return capsule. Dr Ian Franchi of the Open University is one of the researchers who has studied Stardust samples here in the UK.

"Most of the analysis we perform has been using a NanoSIMS – a large instrument similar to an electron microscope," explains Franchi. Like Joy's lunar meteorite studies, his analysis of cometary dust illuminates a much wider story than that of just one tiny fleck.

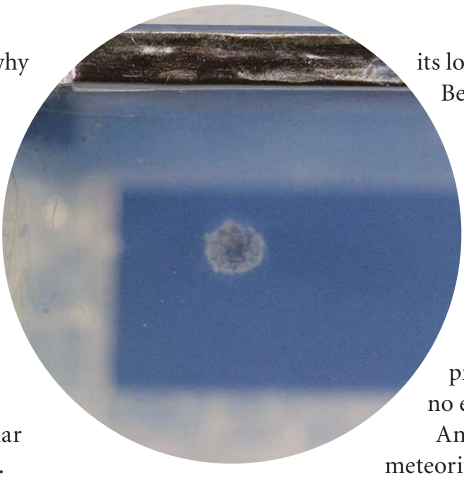
"One of the major challenges we face in the study of Solar System formation is trying to put a 'map' together of where and when different materials formed in the early Solar System," explains Franchi. "The materials that have survived the [Stardust] capture process are generally the larger fragments. These appear to be very similar to those materials we find in meteorites, which is very interesting as these materials most likely formed in the inner regions of the protoplanetary disc and were transported to the outer regions of the disc where comets formed."

Answers close to home

As well as his research analysing the material returned by the Stardust spacecraft, Franchi is today involved with another NASA sample-return mission, OSIRIS-REx, which will begin its long journey to the asteroid 101955 Bennu later this year.

He's also leading a proposal to ESA for a mission that would retrieve material from an asteroid. "One of the great aspects of sample-return missions is that when a new scientific question arises, or new instrumentation is developed, these can be readily applied to samples already returned (a portion of which are always preserved for future generations) at virtually no extra cost," says Franchi.

And, perhaps, that's the nub of why many find meteorites and sample-return missions so thrilling; as we slowly amass fragments of other planetary bodies here on Earth, it may be in a lab on our own world, rather than on an alien landscape, that we make the most profound discoveries about the Solar System we live in.



▲ Stardust's aerogel collector snared dust from comet Wild-2; though it looks innocuous, this blob is wildly exciting

OSIRIS-REx will launch for its target asteroid in late 2016, returning its samples in 2023

NASA, NASA GODDARD SPACE FLIGHT CENTER, NASA/JPL-CALTECH

RICHES ON THE HORIZON

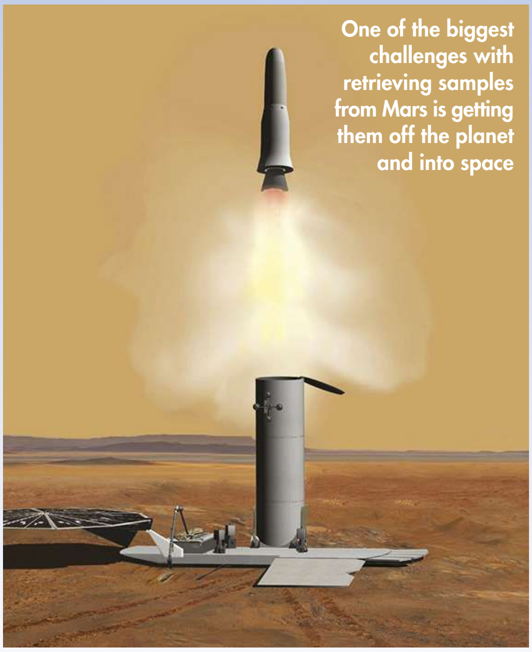
Future missions will not only survey our neighbours, but bring back valuable samples for analysis

In recent years Mars has been at the forefront of discussions about sample-return missions. The problem is that collecting and packaging specimens robotically before launching them safely off the planet is no simple task, and with crewed missions to the Red Planet not anticipated for many years the dream of a delivery of Martian rocks to Earth seems a long way off.

Not so for other targets in the Solar System. NASA's OSIRIS-REx mission is set to launch to asteroid 101955 Bennu this year. There it will gather samples of the asteroid's surface before conveying its valuable cargo back to Earth.

Dr Ian Franchi of the UK's Open University is one of the scientists who'll get to study that material when it arrives here in 2023. "There is a vast amount of science that will be undertaken," he says. "We will have high quality, 'ground truth' information for the first time, to link the remote spectral information from telescopes with a detailed understanding of the mineralogy and chemistry of the surface materials and how these materials were formed."

Franchi is also part of a team proposing an ESA mission – MarcoPolo – that would return samples of a D-type asteroid. "D-type asteroids formed in the outer regions of the protoplanetary disc, probably in similar regions to where comets formed," he says. "Samples from a D-type asteroid will contain some of the most primitive materials available in the Solar System." By studying these materials researchers may be able to shed light on the history of our planetary system and even the emergence of life on Earth.



One of the biggest challenges with retrieving samples from Mars is getting them off the planet and into space

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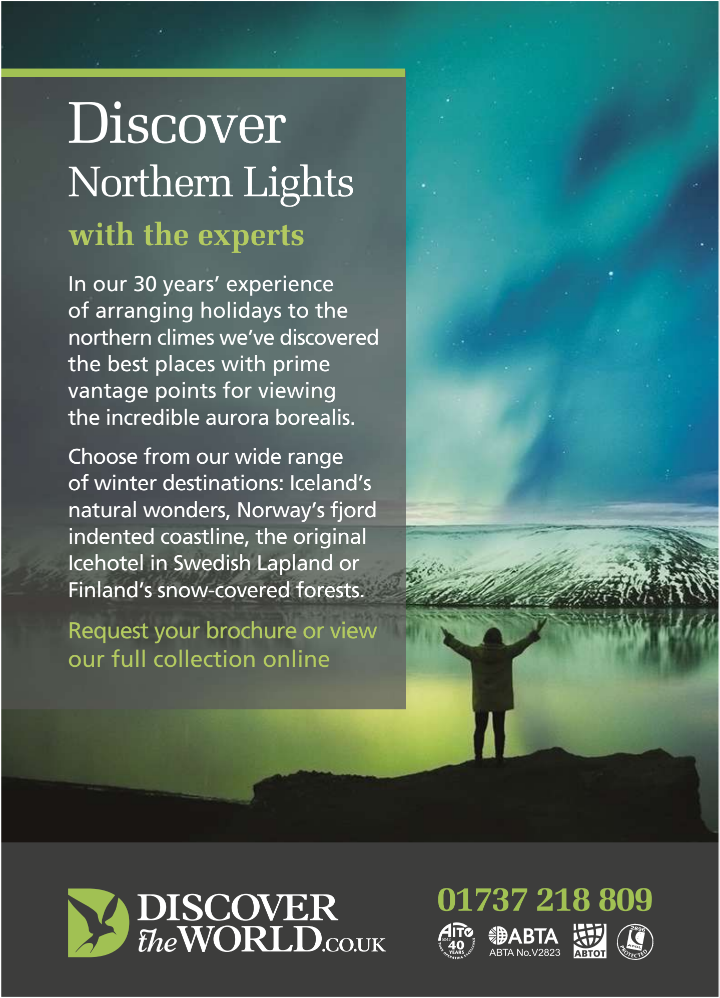

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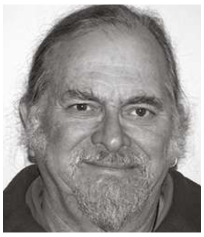


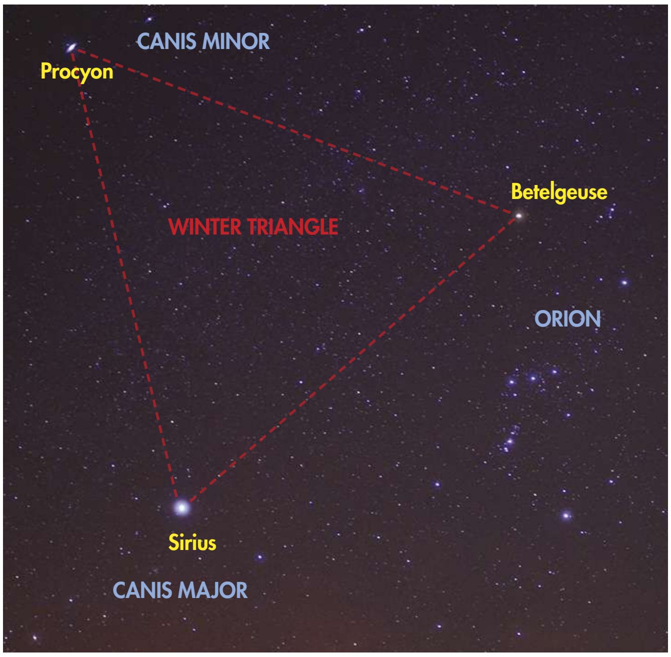
The Guide

Your first steps in star hopping

With **Stephen Tonkin**

The tried and tested technique that will help you to navigate the sky

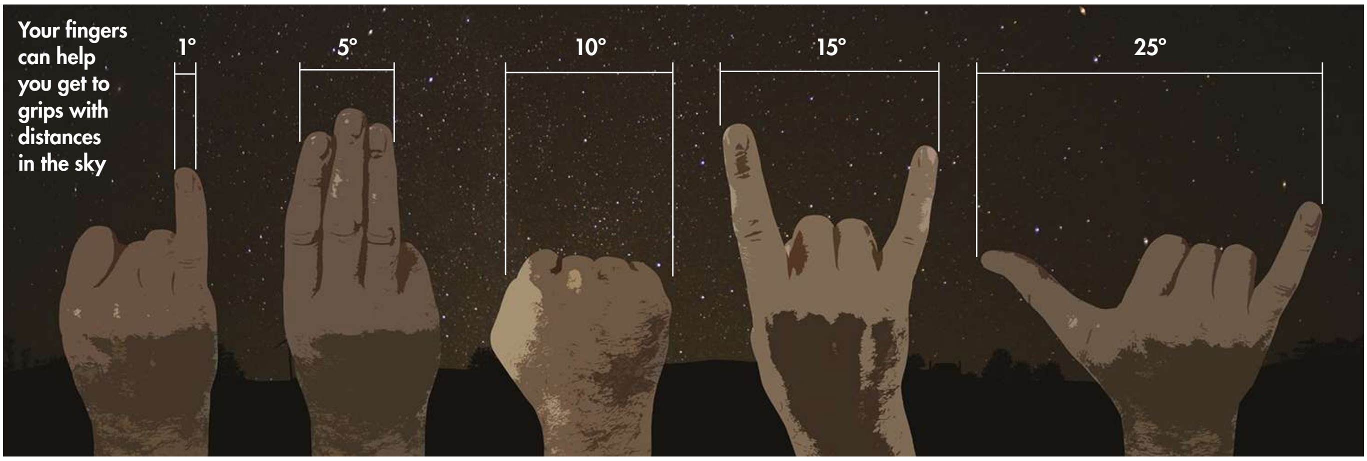
▲ Once you have estimated the distance between two bright stars, you can use that knowledge to move into less familiar regions of the night sky



▲ Bright star patterns such as the Winter Triangle are more than targets to tick off – use them to help you navigate to more challenging objects

For those new to astronomy, staring into the clear night sky and seeing hundreds of points of light can lead to a common conundrum: how will I ever find my way around this bewildering confusion of stars? One way is to buy a telescope with a Go-To mount, which can take you to any object in its database at the press of a button. But there is a much simpler alternative, tried and tested over thousands of years, which experienced observers still use to find objects we cannot see with the naked eye. We call this star hopping.

The brighter stars form recognisable patterns – constellations, asterisms, and even simple geometric shapes – and we can use those patterns as 'jumping off' points to less obvious and fainter regions or objects of interest. Some of these shapes may be contained within a single constellation, as is the case with the Plough in Ursa Major and the W of Cassiopeia, but others can stretch across


Your fingers can help you get to grips with distances in the sky

ISTOCK X 4, CHARTS BY PETE LAWRENCE

several. Take the Winter Triangle for instance: its spans Orion, Canis Minor and Canis Major.

All you need for this remarkably useful technique is a star chart, a red light torch so you can read it outside without compromising your night vision, and some way of measuring the angles between objects. For this last instrument we're fortunate that nature has already provided us with a rudimentary angle measurer: the hand at the end of your outstretched arm offers an easy approximation of angles ranging from 1° to 25°, as shown in the diagram on the previous page. An alternative to a star chart is a planisphere, which can show you the sky for any date and time. If you have a planisphere, set the time on the hour ring to the day on the date ring and it will show you the sky above you.

Search for patterns

One thing you will need to practice is relating the scale of your star chart to the scale of the sky. Find a constellation or asterism in the sky and then locate the same group on your chart: you will probably be surprised at how much bigger it looks in the sky! Now look for other prominent groups of stars on your chart and locate them in the sky, trying to keep the relative scales in mind. Reverse and repeat. Take your time with this: you are building a firm foundation that will serve you well for the rest of your observing career.

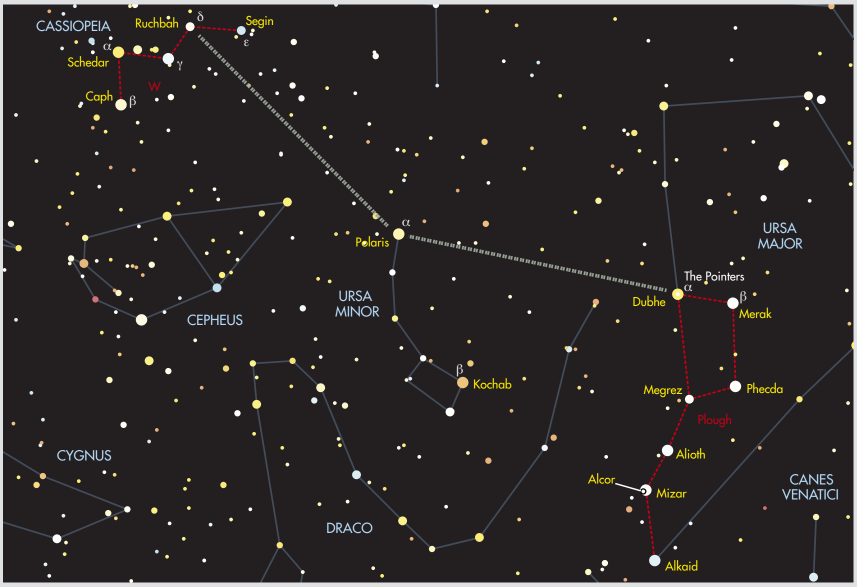
The key to star hopping is accurately estimating directions and distances. For directions, use pairs of bright stars that approximately align to your target object. If no such stars are available, we may estimate angles from lines of stars. We can compare the distances we want to the distances between bright stars. Alternatively, if we know the angular distance from a star, we can use our hands to estimate those distances. When you transfer these skills to binoculars or telescope finders, make sure you know the angular diameter of the field of view, as you can use this to estimate angular distances.

Start with the star hops suggested here, then devise some of your own. With a bit of practice, the bewildering confusion will become a familiar playground for you to navigate with confidence. S

Stephen Tonkin is an expert observer who writes our *binocular tour* each month

FINDING THE POLE STAR

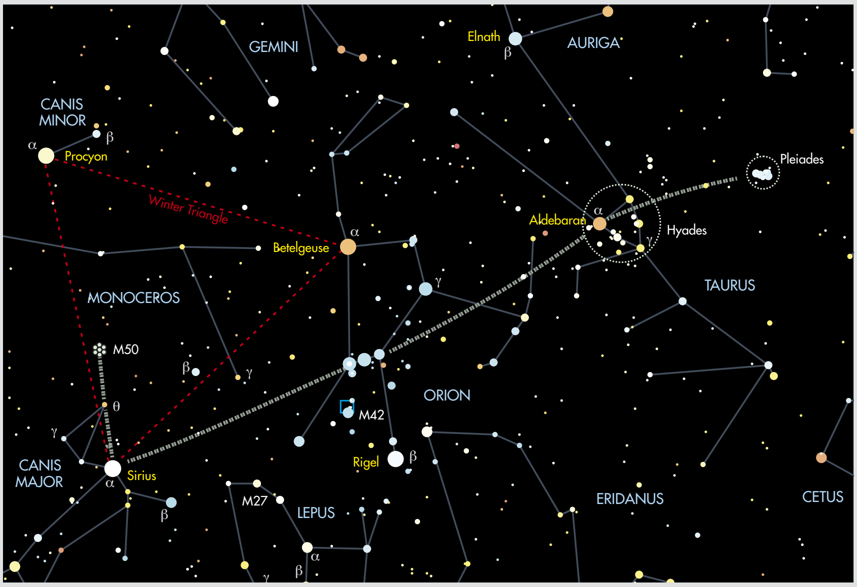
The ability to locate the north celestial pole is fundamental to astronomy. If you can see the Plough asterism in Ursa Major, just use the 'Pointers' Merak and Dubhe (Beta (β) and Alpha (α) Ursae Majoris). These lead directly to the pole star, Polaris (Alpha (α) Ursae Minoris), which is slightly more than a hand span from Dubhe. If the Plough is obscured, use the wider 'V' of Cassiopeia's W and divide the V angle into thirds. Take a line through the third of the angle nearest Segin (Epsilon (ε) Cassiopeiae) and extend it by one hand span.



LEARNING YOUR WAY AROUND THE SKY

Extend a line through Orion's Belt northwest for 22°, where you will find a bright orange star, Aldebaran (Alpha (α) Tauri), at one tip of a V of stars. This is the Hyades open cluster. Now extend it 14° farther on and you will find the Pleiades open cluster, commonly called the Seven Sisters. Return to Orion's Belt and look about 20° southeast to the bright star Sirius (Alpha (α) Canis Majoris) which, with Betelgeuse (Alpha (α) Orionis), is part of the Winter Triangle asterism. Imagine that Sirius and Betelgeuse are the base of an equilateral triangle. At the other apex is the third star, Procyon (Alpha (α) Canis Minoris).

We'll finish with a binocular star hop. Start at Sirius and look 5° towards Procyon, where you will find the star Theta (θ) Canis Majoris. Nearly the same distance further on lies M50, an open cluster that will appear as a fuzzy patch in your binoculars.



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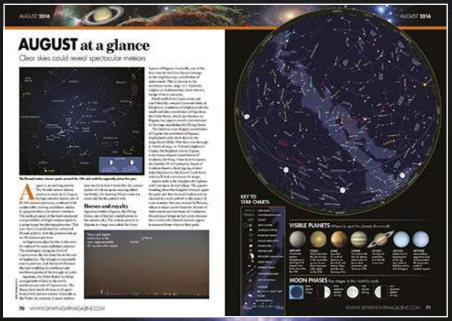

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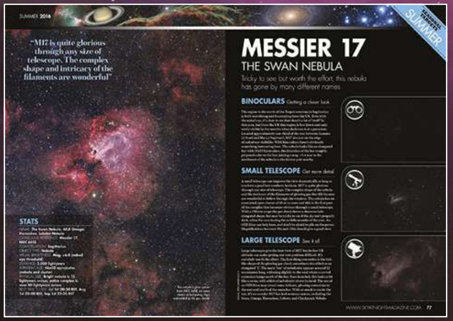

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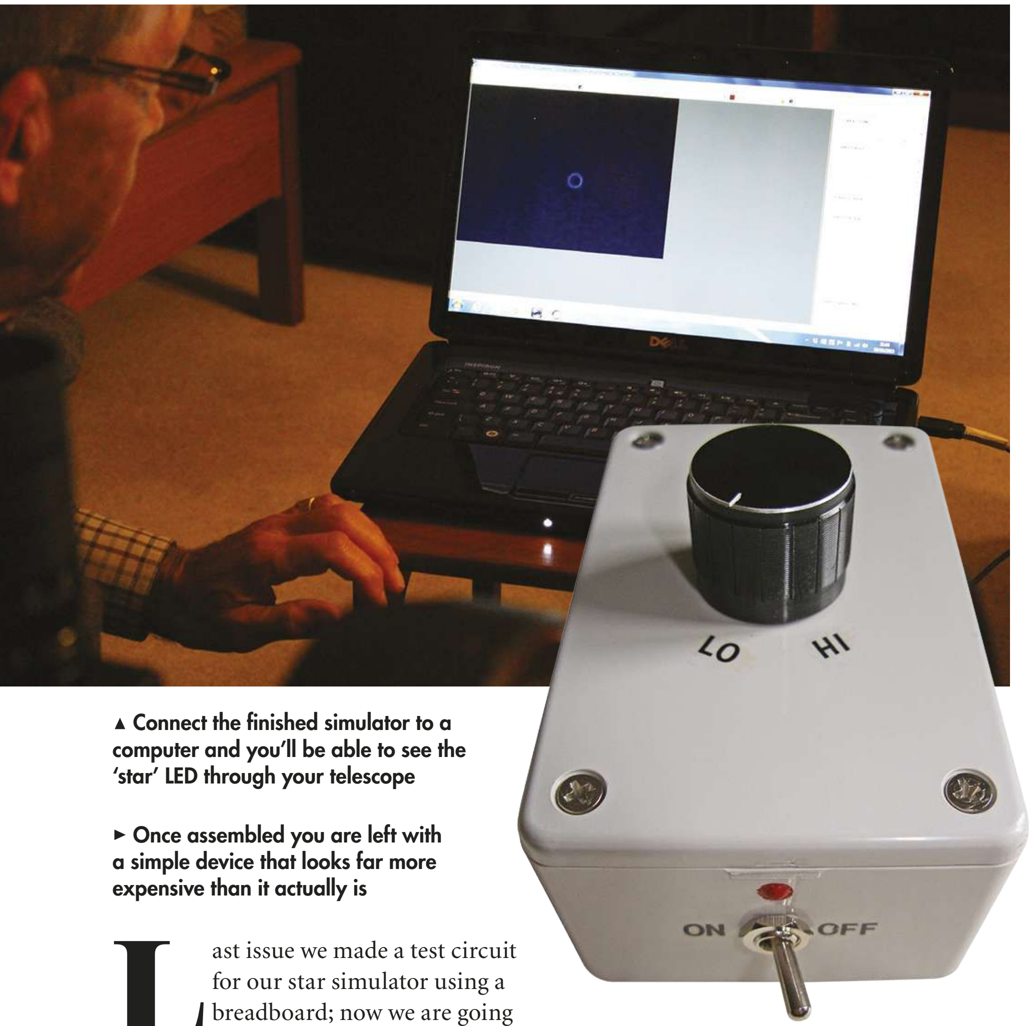
With **Kim Clark**

How to

Build a star simulator PART 2

Assemble the components and finish this indoor accessory



▲ Connect the finished simulator to a computer and you'll be able to see the 'star' LED through your telescope

► Once assembled you are left with a simple device that looks far more expensive than it actually is

TOOLS AND MATERIALS

TOOLS
Long-nosed pliers, 'mini' wire cutters, wire strippers, fine-tipped soldering iron, lead-free solder, junior hacksaw, electric drill and bits, needle file, bradawl, pocket multimeter.

ELECTRONICS
Project box with integral PCB guides, two stripboards to suit inner box depth, precision 10µm pinhole in mount, 5mm LED bezel mount, 16/0.2mm 3A stranded equipment wire, plus the components from part one.

SUNDRIES
Fuse wire (5 amp), insulating washers and tape, small 'seat buffer' to retain pinhole mount, cardboard disc to simulate mount diameter, marker pen, methylated spirit, dust mask, safety goggles, lacing cord or similar.

Last issue we made a test circuit for our star simulator using a breadboard; now we are going to package these components into a device you can actually use.

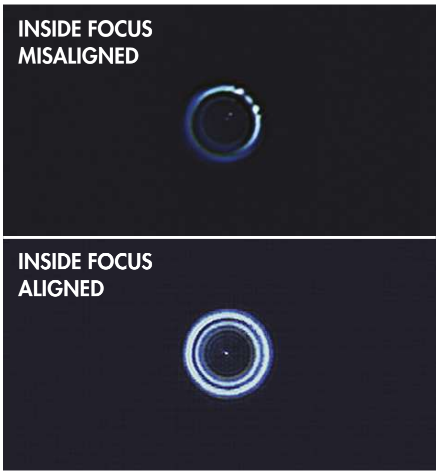
In addition to the electronics mentioned in part one, you also need a project box with integral PCB guides and a 'star mask'. The latter comprises a precision pinhole in ultra-thin foil and mounted in a 25mm diameter aluminium disc to provide a well-defined and bright 'star' source. We can determine the 'star' size, using basic trigonometry and applying the Dawes' limit values usually to be found in the specifications for your telescope. For a 4- to 5-inch reflector this works out at 13µm over a test range of 6.6m; for comparison, the thickness of a human hair is 17µm. Precision pinholes are typically (but not exclusively) available in 5µm increments, so a 10µm size will give good resolution to an intense spot of light, such as given out by a bright white LED, at the set distance specified when directed through its microscopic hole.

Mark out and drill the end faces of the enclosure for the 'star' aperture, and the switch and indicator LED holes. If required you can also drill the base of the enclosure to take a standard camera tripod attachment. Stripboards will form the basis of our permanent, soldered circuits. It is important when cutting and filing board to always wear a mask to prevent dust inhalation. Cut the stripboards with a junior hacksaw to fit width-wise between the integral guides, copper sides facing in.

Pilot drill the stripboard that will hold the 'star' through the 'star' aperture in the enclosure box, then remove the board and open the bezel hole in steps to full size. Install the toggle switch and shape the rear board around it, maintaining two full tracks above to act as positive and negative rails. Cover the top of the switch casing with insulating tape to isolate it from the copper strip.

Drill a hole in the enclosure lid for the potentiometer. Mark the 'HI' and 'LO' (maximum and zero LED intensity) positions on the outside. Solder the potentiometer leads to the terminal lugs. Check this by connecting multimeter ►

ALL PICTURES: KIM CLARK



▲ **The 'star' as seen by a laptop when the scope is misaligned (top) and well collimated (bottom)**

▸ leads as follows: positive to the output (red wired) terminal and negative to the input (centre yellow wired) terminal. With the meter set to ohms turn the shaft between extremes. 'HI' should indicate 0Ω and 'LO' 4.7kΩ.

Remove the stripboards from the enclosure, then complete basic assembly by fitting the 'star' – the LED and bezel combination to the front board using insulating washers. Insert a short length of wire insulation through the top centre hole in the rear board. Feed the indicator LED anode through this and the cathode through the hole below. Continue to make solder connections, mimicking the breadboard layout from part one. Replace the boards in the enclosure, routing and tying the wiring back to clear the battery partition. Proceed with the pinhole mount installation as described in the documents available in this month's Bonus Content.

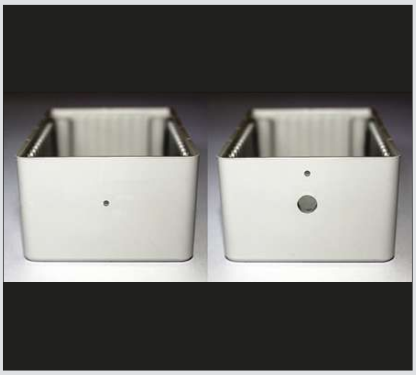
To use the star simulator, position it at 6-7m distance from the telescope and at the same height as its optical axis. Switch the unit on and adjust the intensity of the simulated star. With the aid of a webcam and laptop, obtain the view of the star using the telescope's focuser. Defocus slightly to check for skewed images such as in the topmost of the images above. Make small adjustments to the collimation while monitoring the view on the laptop screen, until the out of focus rings are concentric and collimation is achieved, as seen in the lower of the images above. Ⓢ

Kim Clark is an amateur astronomer and a keen maker of astro-imaging devices

YOUR BONUS CONTENT Extra resources to help you complete this project

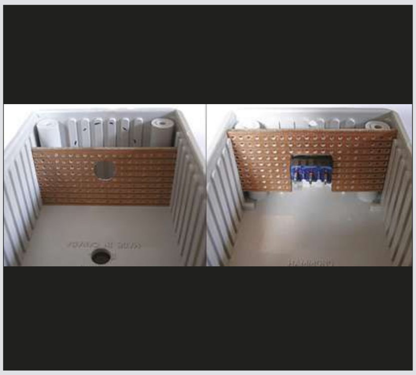
ALL PICTURES: KIM CLARK

STEP-BY-STEP GUIDE



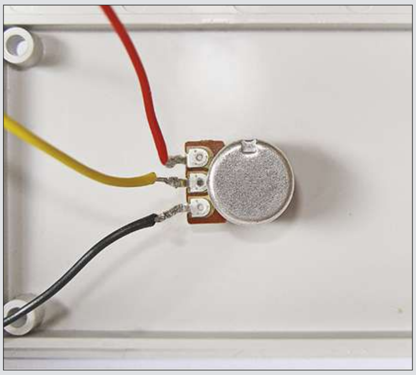
STEP 1

Work out the enclosure box's centre line on the long axis. Position the 'star' hole 16.5mm from one top edge and drill 3mm diameter (left). At the other end, position the indicator LED and switch hole 5mm and 15mm down (right). Drill 3mm and 5.8mm diameters respectively.



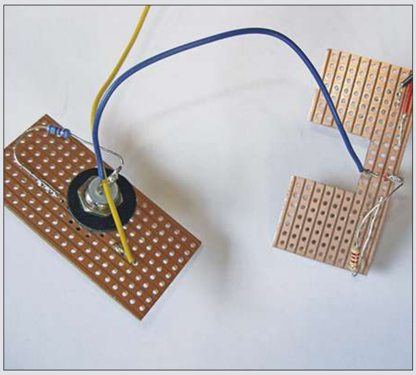
STEP 2

Cut two stripboards to fit between the guides. Drill a 3mm hole into the 'star' board (left) and open to 8mm. Mount the switch and cut the board to fit around it, leaving two complete tracks above. Cover the top of the switch (right image) with insulating tape.



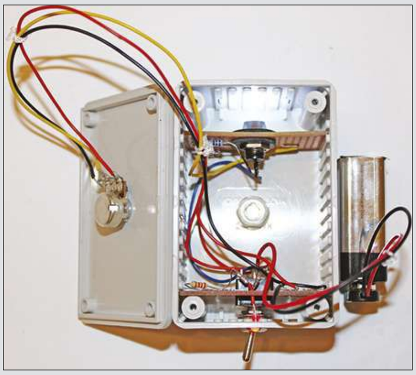
STEP 3

Mark the centre of the enclosure lid and drill a 6.8mm hole. Mount the potentiometer so that the extremes of rotation are equal about the long centre line. Cut and bare three 250mm-long wires (red yellow and black) and solder them to the terminals.



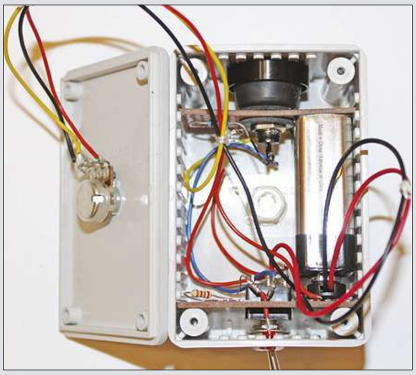
STEP 4

Attach the LED/bezel to the 'star' stripboard with insulating washers. Solder the 270Ω resistor to the LED anode and board. Cut and bare a 75mm length of blue wire and solder one end to the 'star' cathode. Complete connections as per the circuit from part one.



STEP 5

Replace the interconnected strip boards in the enclosure. Connect the battery snap and switch it on to verify that the indicator LED works. Fit the potentiometer knob, aligning the reference mark with the HI/LO annotations. Also check the 'star' LED varies in brightness.



STEP 6

Install the precision pinhole mount followed by the battery, taking care not to dislodge any solder joints. Paint the rear flange of the 'star' LED black to prevent light leakage into the enclosure. Check the unit operates once more, then fit the lid/potentiometer assembly.

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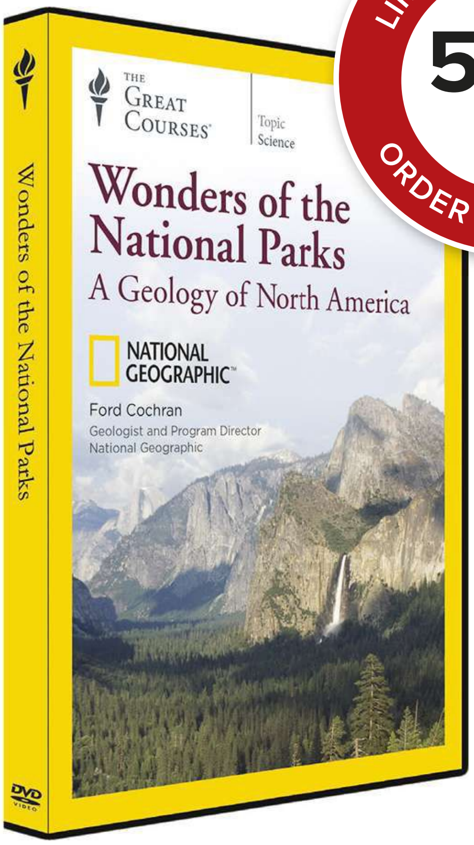
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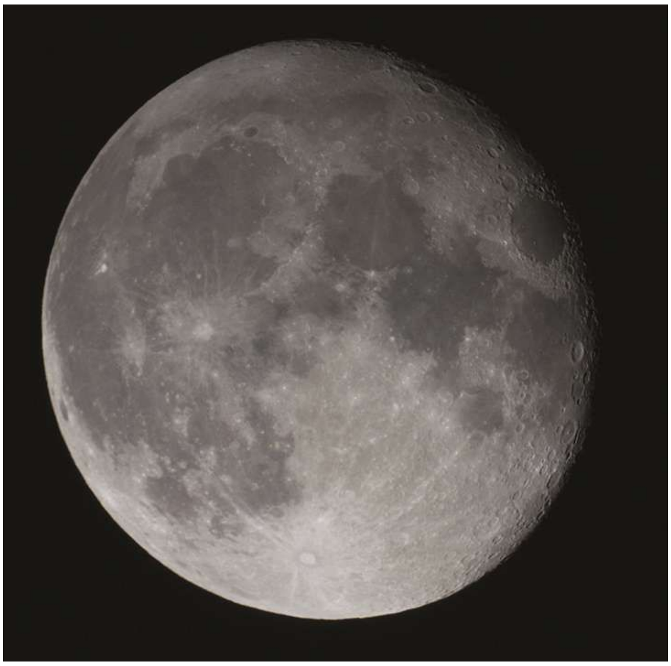
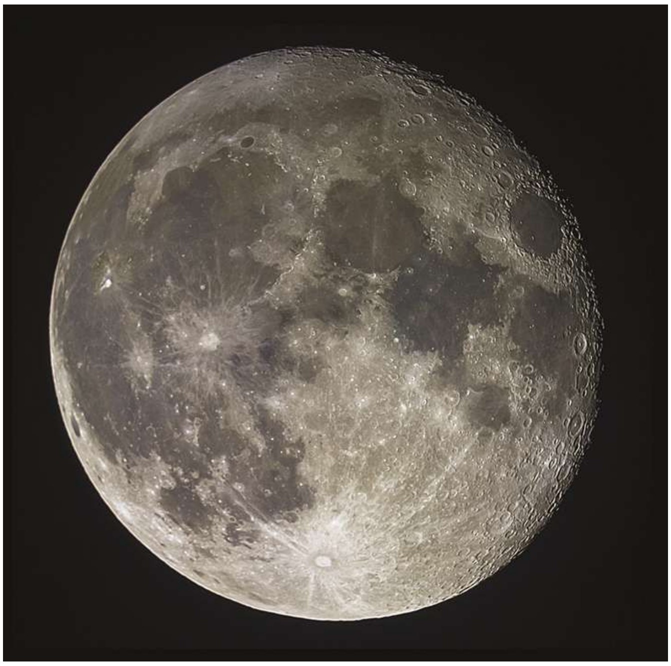


▲ Our starting image of the Moon, taken with a Canon EOS 1100D DSLR through an 8-inch Ritchey-Chrétien telescope with focal-reducer

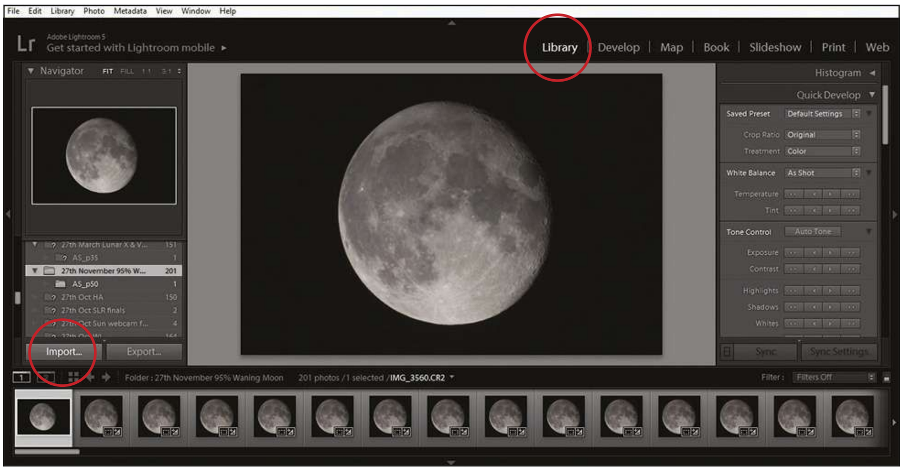


▲ Our final edited shot, showing much greater distinction between the lunar highlands and maria, not to mention greater surface detail

In this tutorial we are going to look at how you can 'denoise' lunar and solar images using Adobe Lightroom. Noise can make your images look grainy, and removing it brings myriad benefits. In lunar images, you can add definition and depth to the Moon's surface by enhancing craters and highland regions, and bring out more colour across the maria. In solar images, sunspots, filaments and prominences can be enhanced. Here, we will walk through the steps needed to enhance lunar images, but the same basic principles can be applied to solar ones too.

Our starting image was taken with an 8-inch Ritchey-Chrétien telescope fitted with a 0.67x focal reducer and a Canon EOS 1100D DSLR. For the best results, you should take your images as RAW files, as this will give you a higher resolution starting point and make processing easier.

ALL PICTURES: MARY SPICER



Saved Preset: Default Settings
Crop Ratio: Original
Treatment: Color
White Balance: As Shot
Tone Control
Folder : 27th November 95% Waning Moon 201 photos /1 selected /IMG_3560.CR2
Filter : Filters Off

▲ Select the images you want to process with Import; make sure you are on the Library tab

Note that if you are planning to stack your shots in either Autostakkert! or RegiStax that neither can handle RAW files. One of the reasons we are using Lightroom is that its batch processing function can convert them into Tiff format. This stage is simple, and if you also crop your images at this point it reduces the file sizes, something that helps the stacking software to run faster. If you do not wish to stack images, just open your image as described below, then move straight to the tweaking of the final image.

Start by cropping

Open Lightroom and make sure you are on the Library tab. Click the Import button, select your images, then click Import. Now move onto the Develop tab. From the top navigation menu, select **Tools** > **Crop**. Drag the edges of the box around until you are happy with the crop area, then hit Enter. To apply the crop to the rest of your images, click **Edit** > **Select All**, then click **Copy** > **Check All** > **Copy**. Hover your mouse over the photos at the bottom, then right click and choose **Develop Settings** > **Paste Settings**.

Now you need to export your images. Make sure all images are selected, then click **File** > **Export** to bring up the export window. It is helpful to put your exported images into a new folder, so check the Put In Subfolder box and type in a folder name. Using the scroll bar, move down to the File Settings menu and select Tiff. Then click Export and wait until your files have been saved.

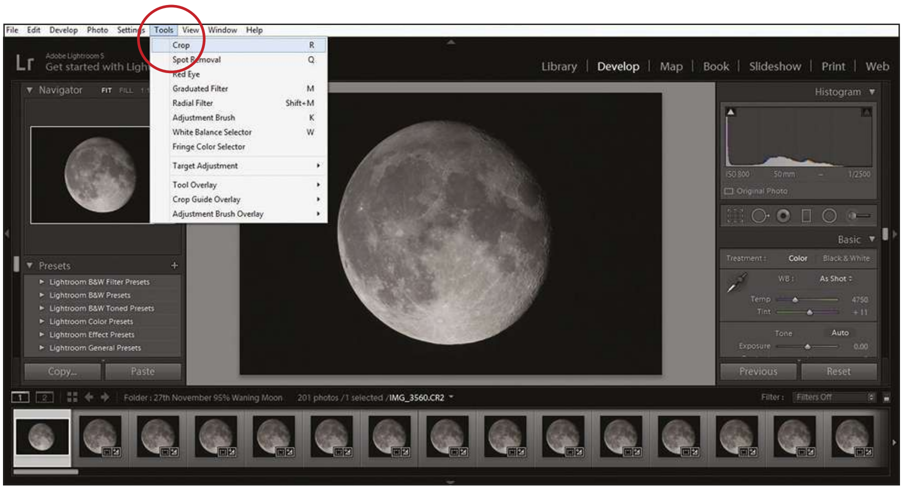
Now you are ready to stack your images. Once you have done so, follow the same import process as before and make sure you are on the Develop tab. The image we will use for the next part is a stack of 100 Tiff files.

Editing with sliders

The adjustments to remove noise are all made using the sliders on the right of the Develop tab. There is no single correct set of values you should be using: every image will need different processing. Personal taste plays a part too, so play with the sliders and decide which adjustments are right for your shot.

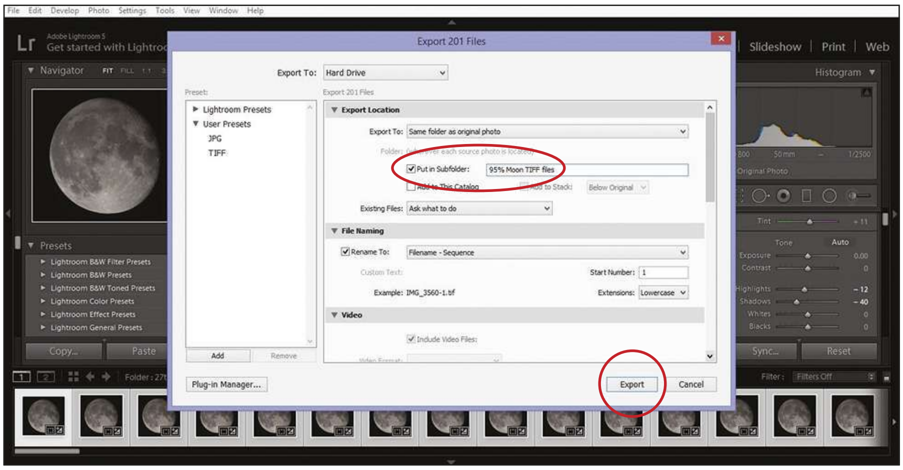
A good place to start is with the Highlights and Whites sliders. Highlights adjusts the overall brightness of the lunar surface, whereas Whites enhances the brighter, highland areas. Make small adjustments until you are happy with the balance of the two, taking care not to blow out the white areas, then move on to the Shadows and Blacks sliders. Once again be careful not to push these too far, but alter them just enough to give a nice level of contrast between the maria and highland regions.

Next you can adjust the Clarity slider. This is the slider that can most easily wreck your image, so use a very gentle hand. Underneath the Clarity slider you will find ones for Vibrance and Saturation. Increasing these will highlight the different basalt compositions within the maria, but pushing them up too far will make the image look very artificial. More minor tweaks can then be made using the Tone Curve sliders. Move down into the Noise Reduction section and alter the Detail slider to reduce graininess. The amount needed will depend on the quality of your image; too much will make the image blurred. When you are happy with the image, export it in the same way as described previously, but this time select Jpeg instead of Tiff for the export. This will give you a final image which is a suitable file size for sharing online.



Folder : 27th November 95% Waning Moon 201 photos /1 selected /IMG_3560.CR2

▲ Cropping your images prior to stacking can lower your overall processing time



Export To: Hard Drive

Export Location

Export To: Same folder as original photo

☑ Put in Subfolder: 95% Moon TIFF files

☐ Add to This Catalog

Existing Files: Ask what to do

File Naming

☑ Rename To: Filename - Sequence

Start Number: 1

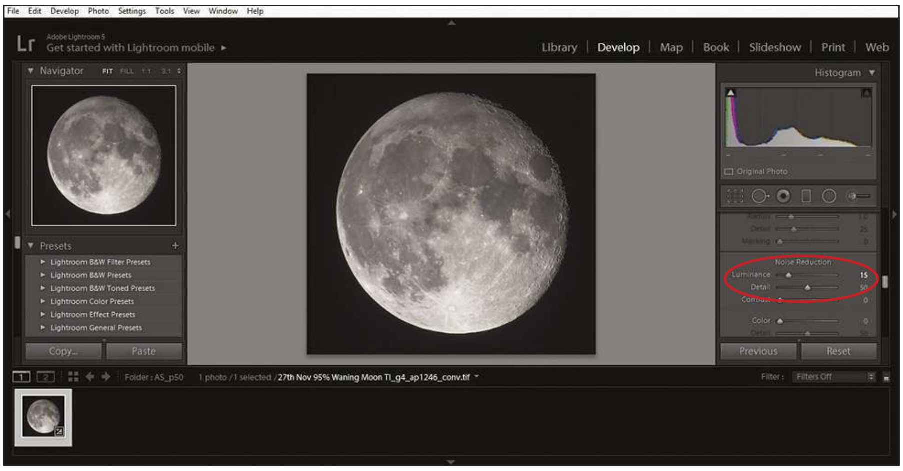
Example: IMG_3560-1.tif

Extensions: Lowercase

Video

☑ Include Video Files:

▲ You need to export the images from Lightroom to stack them – save them in a different folder


File Edit Develop Photo Settings Tools View Window Help
Library | Develop | Map | Book | Slideshow | Print | Web
Navigator
Histogram
Presets
Noise Reduction
Luminance
Detail
Contrast
Color
Copy... Paste
Previous Reset

Folder : AS_p50 1 photo /1 selected /27th Nov 95% Waning Moon TI_g4_ap1246_conv.tif

▲ The sliders in Lightroom's Develop tab can alter graininess, contrast and more

Mary Spicer is a passionate astro imager based in Oxfordshire

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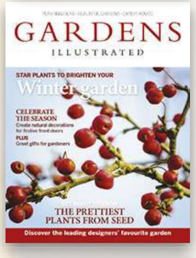

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Scope DOCTOR

With **Steve Richards**

Our resident equipment specialist cures your optical ailments and technical maladies

▲ Sky-Watcher Nirvana UWA-82° eyepiece (left) and Baader Genuine Ortho 5mm eyepiece

Can you advise me on the best eyepieces for planetary observing for a budget of £150-200?

SUSAN TAYLOR

It is important to consider the telescope that will be used when selecting suitable eyepieces. The planets require high magnifications to view them close in, so most amateur astronomers opt for an instrument with a long focal length. However, the general seeing conditions from your location should also be considered when deciding on the type of eyepiece that you should purchase.

On most nights, the seeing will limit your magnification to a maximum of 250x. Seeing, in an astronomical context, is a description of how much celestial objects appear to shimmer through changes in the refractive index of Earth's atmosphere as a result of turbulence.

With this in mind, the smallest focal length of a suitable eyepiece can be found by dividing the focal length of the telescope by 250. A typical telescope with a focal length of 1,000mm would, therefore, take a 4mm eyepiece in typical conditions or perhaps one with a shorter focal length if the seeing is exceptional.

Relying on a single eyepiece is not ideal – purchasing at least two or three would make better sense. Very wide fields of view are not needed for planetary observations and the multiple lens groups required for very wide field eyepieces can cause unwanted reflections with the brighter planets, so Plössl or orthoscopic eyepieces make good choices. William Optics SPL, Baader Classic Orthoscopics or Sky-Watcher UWA Planetary Eyepieces should feature in your shortlist.

STEVE RICHARDS, WWW.TELESCOPE.COM X 2

STEVE'S TOP TIP

What is the difference between an altaz mount and an equatorial mount?

An altaz mount tracks objects as they move across the sky by making both small vertical movements (altitude) and similar small horizontal movements (azimuth) in discrete steps.

An equatorial mount, however, has two axes known as right ascension (RA) and declination (dec.). The RA axis is pointed to the north (northern hemisphere) or south (southern hemisphere) and tilted at an angle to match your latitude. Once an object is located through the telescope, rotating the RA axis alone allows the telescope to track the object accurately as it moves in a smooth arc across the night sky.

I want to get my kids into astronomy. Can you suggest a good starting setup for around £100?

KEITH PRESTON

▲ The Sky-Watcher Heritage 100P Dobsonian is a simple starter scope

For beginners there are essentially two kinds of telescope, Newtonian reflectors and conventional refractors, both of which are suitable for youngsters.

Telescopes require a suitable mounting. The simplest and most intuitive to use is the Dobsonian mount, which comprises a Newtonian reflector mounted on a simple wooden base that moves left and right and up and down by simply pushing it in the desired direction. Refractors, on the other hand, tend to be supplied on a geared equatorial mount, which moves in an arc to follow the movement of celestial objects across the sky by adjusting a simple hand wheel on a flexible shaft.

Children tend to appreciate the appearance of refractors the most because they look like a 'proper' telescope and for them, this is an important factor to capture their imagination. Within your budget, consider either Celestron Astromaster 70 EQ equatorial mounted refractor or, for a reflector, the Sky-Watcher Heritage 100P Dobsonian.

Steve Richards is a keen astro imager and an astronomy equipment expert

Email your queries to scopedoctor@skyatnightmagazine.com

The Infinity

For stunning views in seconds.

The Infinity breaks the barrier between visual observing and astrophotography. It combines the experience of observing at the eyepiece with a level of depth and detail that would traditionally be the result of several hours processing. This takes a camera that's sensitive enough to capture faint details on distant objects, and fast enough to do it in real time. It then takes our powerful, intuitive software to bring stunning views of the night sky to a screen in just seconds.

This recreates the feel of observing in the field through a very large telescope, only using much more modest equipment. You stay connected to the night sky, watching satellites drift across your field of view, while viewing objects previously out of reach to all but the most powerful eyepieces and the largest apertures.

See the faint connecting filaments in M51 while planning your next move in your star atlas. See bok globules in the Pelican Nebula as you dodge the clouds. Dive deep into the NGCs of Andromeda - and do it all in colour.

Although our eyes aren't sensitive enough to see the universe in colour, the Infinity is. Faint grey fuzzies become detailed areas of colourful nebulosity, allowing you to go beyond the limits of our vision.

But our own vision isn't our only limitation. Light pollution is a growing problem for all of us, with backyard observing becoming increasingly difficult in many places. The Infinity helps you cut through the pollution to bring observing back to our urban areas.

It also helps you share the breath-taking things we see and discover as astronomers. By cutting the queue to the eyepiece, the Infinity allows everyone to explore the night sky not just together, but at the same time. You can discuss details and anomalies as you see them, and remove the need for special skills in averted vision.

This makes it the perfect tool for public outreach, as well as observing with family and friends. But the Infinity doesn't just provide you with incredible live views. It also allows you to save single images and even whole sessions to share later. You can even broadcast your session live online to a global audience, right from inside our software.

But surely something this advanced involves additional specialist equipment and complex software? That's the best bit. The Infinity is designed to work from a focal length of around 300mm right through to 1500mm. It works with alt/az fork-mounted telescopes as well as equatorial mounts. As long as you can track a star for a few seconds, it will work with an Infinity, without the need for complicated guiding systems.

The camera itself uses the latest in CCD technology to provide incredible sensitivity at very low noise, and it's all controlled through our custom built software. You want to spend your time exploring the universe, not learning our program, so we've kept it as simple and intuitive as possible while still giving you the power and control you need to delve deep into the night sky.

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BBC Sky at Night MAGAZINE

Reviews

Bringing you the best in equipment and accessories each month, as reviewed by our team of astro experts

HOW WE RATE

Each category is given a mark out of five stars according to how well it performs. The ratings are:

★★★★★ Outstanding
★★★★☆ Very good
★★★☆☆ Good
★★☆☆☆ Average
★☆☆☆☆ Poor/Avoid

90

We examine the Asteria's unusual approach to dealing with optical aberrations

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This month's reviews

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Gear

104 Including this universal smartphone adaptor

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Find out more about how we review equipment at **www.skyatnightmagazine.com/scoring-categories**

FIRST **light**

See an interactive 360° model of this scope at **www.skyatnightmagazine.com/asteria**

iStar Asteria WFX 150-5 R50 anastigmat refractor

An instrument designed for wide-field views that offers decent imaging potential

WORDS: PAUL MONEY

VITAL STATS

- **Price** £2,155 with Moonlite 2-inch focuser; £2,495 with Starlight Feathertouch focuser
- **Aperture** 150mm (6 inches)
- **Focal length** 750mm (f/5)
- **Optical design** Anastigmat semi apo doublet
- **Mounting** CNC-machined tube rings with Losmandy plate
- **Weight** 15kg
- **Extras** Retractable dew shield, magnetic front cover, 2- to 1.25-inch adaptor with brass compression rings
- **Supplier** Peak2Valley Instruments
- **www.**peak2valleyinstruments.co.uk
- **Tel** 01298 732440

SKY SAYS... We noted a little colour fringing around the brightest stars but overall the view was sharp

WWW.THESECRETSTUDIO.NET X 4, PAUL MONEY

There have been all kinds of refracting telescopes ever since Galileo turned his crude version to the heavens. One thing that quickly became evident was that lenses exhibit various defects, including chromatic aberration, astigmatism and spherical aberration. Modern scopes often employ a triplet of lenses to compensate for such errors, but iStar has taken a slightly different approach with the Asteria WFX 150-5 R50 anastigmat refractor.

The instruments in the 'Rx' series are tuned slightly towards red wavelengths, where the eye is less sensitive. The 6-inch primary lens arrangement has a short focal length of 750mm, making this a fast, f/5 system. The tube itself is manufactured from aircraft-grade magnesium alloy, which is strong and rigid but quite heavy. However, we found our NEQ6 mount with two 5kg counterweights handled it very well.

The telescope tube comes with a retractable dew shield and CNC-machined tube rings. There is also a choice of mounting plate between Vixen or Losmandy – the latter is preferred for the extra stability it gives when attached to the mount.

The Asteria can be ordered with one of two focusers: the standard model is a Moonlite 2-inch dual-speed focuser, or you can upgrade to a Starlight Feathertouch focuser. The latter was supplied for this review. We were loaned the use of the iStar Professional 2-inch dielectric diagonal, again available at extra cost, and found it worked very well with the system. For testing we used our own 26mm and 10mm eyepieces, and 2x and 3x Barlow lenses for added magnification.

Travels in the sky

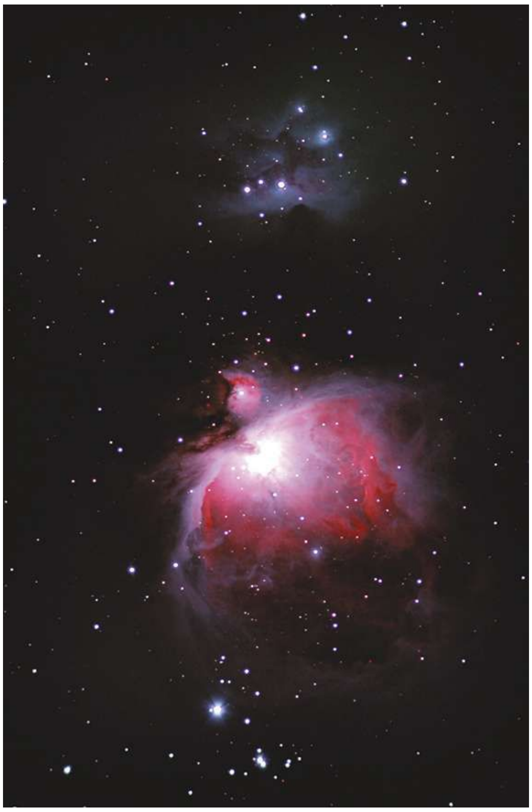
To achieve balance, we found we had to extend the dew shield fully and then carefully move the telescope tube until the front tube ring just touched the rear of the dew shield. After this we found balancing the system even with our Canon EOS 50D DSLR attached quite straightforward.

With the 26mm eyepiece in place we noted a little colour fringing around the brightest stars, but overall the field of view was sharp almost to the edge. Fainter stars showed little or no colour fringing ▸

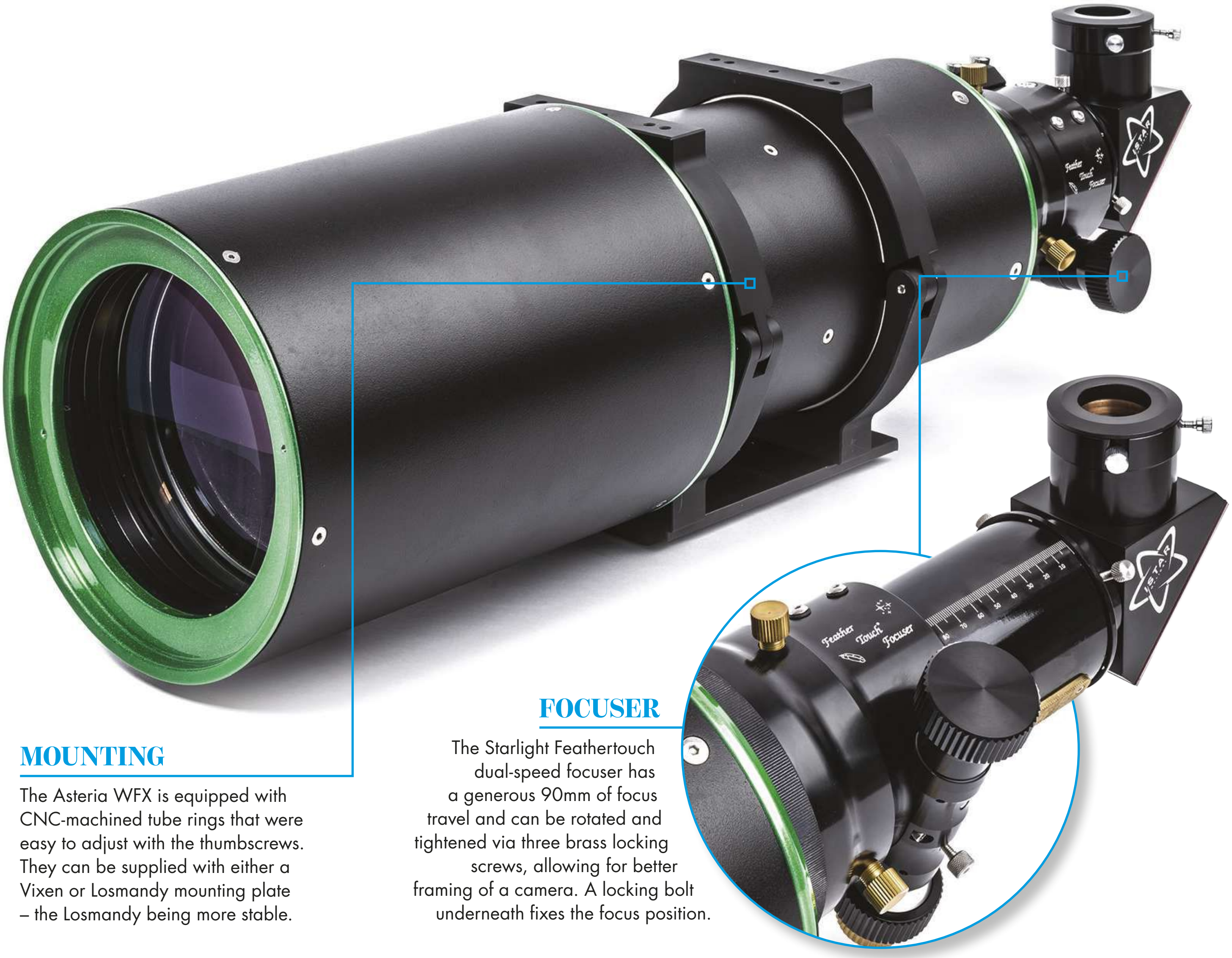
IMPRESSIVE FLATNESS

The Asteria WFX has quite a flat field for such a short focal length instrument. Fast optical systems (ie those with short focal ratios) can suffer from distortion at the edges of the view. The usual solution is to add a flat-field corrector, however this instrument impressed us with its pinpoint stars almost to the field edge, both visually with our 26mm eyepiece and photographically too.

According to iStar, the 'R50' in the optics specs indicates that in bench tests this scope produces a spot size that is 50 per cent smaller than more usual doublet designs, though it will not divulge what glass type is used. We did notice some chromatic aberration creeping in at the edges of our images of the Sword of Orion, but otherwise they held a lot of detail.



▲ **The Sword of Orion, taken with a Canon EOS 50D, stacked from 43, 90-second exposures at ISO 1600**



MOUNTING

The Asteria WFX is equipped with CNC-machined tube rings that were easy to adjust with the thumbscrews. They can be supplied with either a Vixen or Losmandy mounting plate – the Losmandy being more stable.

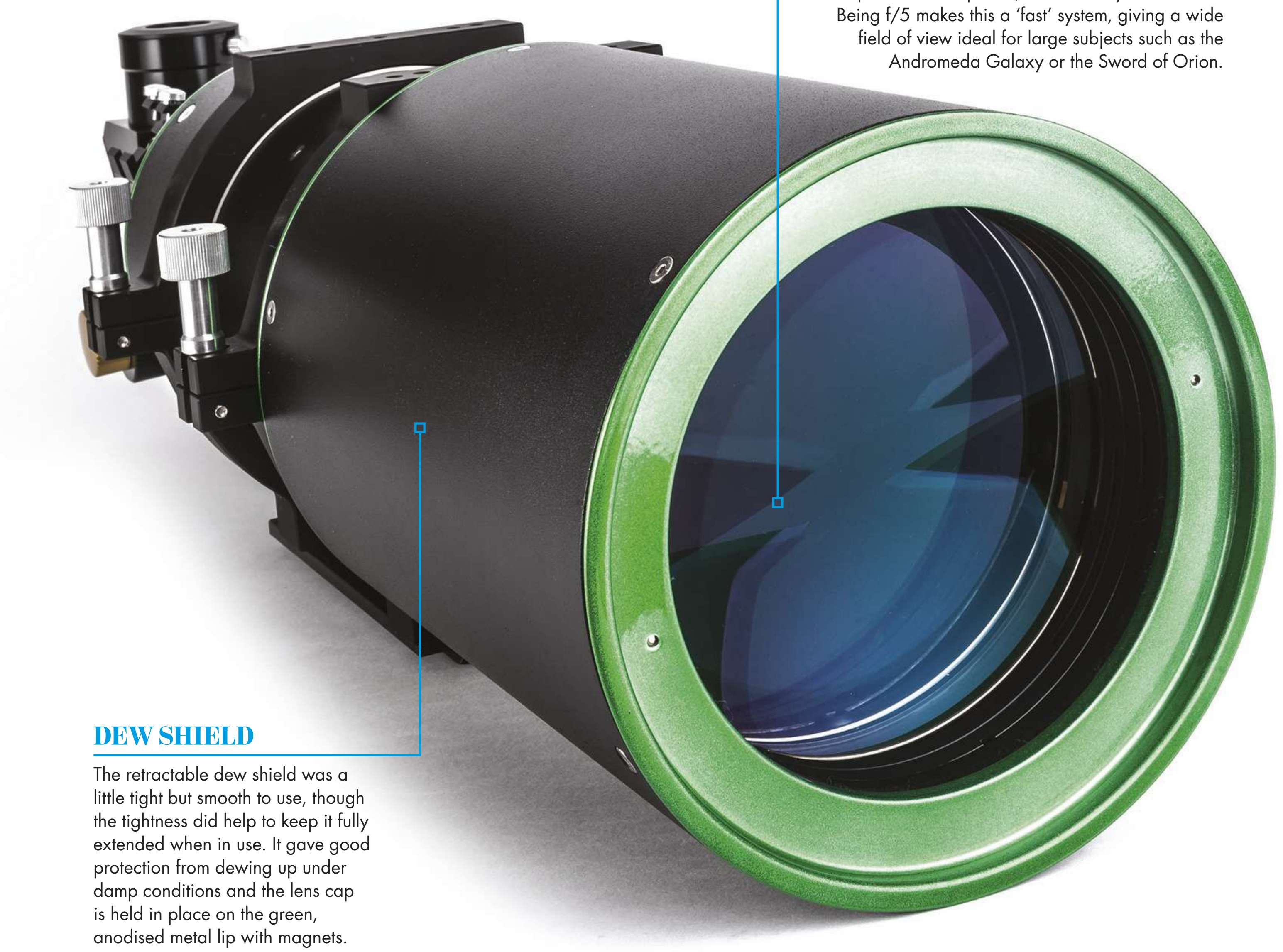
FOCUSER

The Starlight Feathertouch dual-speed focuser has a generous 90mm of focus travel and can be rotated and tightened via three brass locking screws, allowing for better framing of a camera. A locking bolt underneath fixes the focus position.

BODY

The tube is constructed from aircraft-grade magnesium alloy and keeps the optics held firm. The inside of the tube is matt black and baffled to prevent stray light bouncing around inside.

FIRST **light**



OPTICS

The optical arrangement is an anastagmatic semi apo doublet objective, which is fully multicoated. Being f/5 makes this a 'fast' system, giving a wide field of view ideal for large subjects such as the Andromeda Galaxy or the Sword of Orion.

DEW SHIELD

The retractable dew shield was a little tight but smooth to use, though the tightness did help to keep it fully extended when in use. It gave good protection from dewing up under damp conditions and the lens cap is held in place on the green, anodised metal lip with magnets.

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▸ until we cranked up the magnification with the 10mm and 2x Barlow, but bear in mind this system is intended mainly for wide-field views and in that respect it certainly did a good job.

The 26mm eyepiece allowed us to fit the Sword of Orion into the view, from the star cluster NGC 1981 past the Orion Nebula to just beyond Iota Orionis. This gave almost a 2° field of view, ideal for many large subjects such as M45, the Pleiades open cluster in Taurus. While aimed at the Sword we also enjoyed the wreaths of nebulosity visible in the central Orion Nebula, and with averted vision could just see a hint of the Running Man Nebula to the north of it.

The stars of the Pleiades were a resplendent sight, with a hint of the Merope nebulosity hanging away from its namesake star. The Andromeda Galaxy stretched from across the view, its two companions visible along with signs of the dust lanes.

We removed the diagonal and attached a DSLR with an adaptor of our own. We took 43 images of the Sword of Orion, each 90 seconds duration at ISO 1600, and stacked them. Although there were some signs of the colour fringing in the resulting image, especially towards the edges, it was acceptable and showed plenty of detail in the nebulosity. Adding narrowband filters would reduce the impact of colour fringing and make the Asteria WFX a great wide-field imaging system.

VERDICT

BUILD & DESIGN	★★★★☆
EASE OF USE	★★★★★
FEATURES	★★★★☆
IMAGING QUALITY	★★★☆☆
OPTICS	★★★★☆
OVERALL	★★★★☆

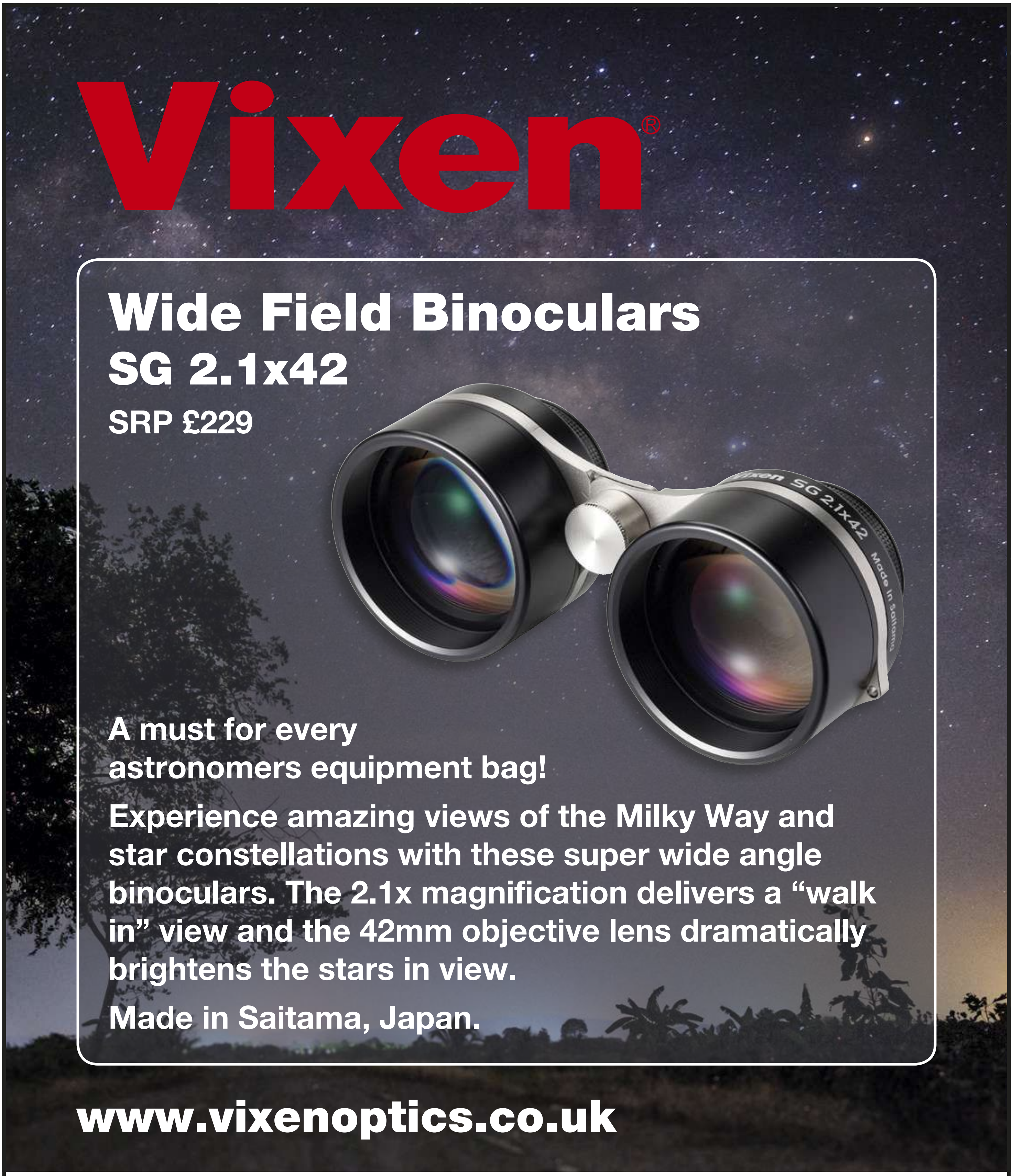
SKY SAYS...

Now add these:

1. iStar Professional 2-inch dielectric diagonal

2. 60mm finder/ guidescope

3. Hard flight case



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FIRST **light**

See an interactive 360° model of this camera at
www.skyatnightmagazine.com/GPCAM

Altair GP-CAM AR0130C colour camera

A great all-rounder for those starting out in digital video imaging

WORDS: MARTIN LEWIS

VITAL STATS

- **Price** £169.99
- **Sensor** Aptina AR0130C CMOS
- **Pixels** 1,280x960 array
- **Dimensions** 63mm long including C-Mount and 1.25-inch barrel
- **Extras** 150° lens, 5mm CS to C-mount adaptor, C-mount to 1.25-inch adaptor, infrared/ultraviolet filter, USB and guide port leads
- **Weight** 70g
- **Supplier** Altair Astro
- **www.altairastro.com**
- **Tel** 01263 731505

SKY SAYS...
We found the camera sensitivity to be high and noise levels to be low

The Altair GP-CAM is an all-purpose CMOS-based USB 2.0 digital video camera, available in colour and mono formats and suitable for Solar System imaging as well as simple deep-sky photography. This review is of the one-shot colour version, which is ideal for those starting out in imaging as there is no need to use separate RGB filters to obtain a colour image. The GP-CAM can also be used for guiding as it is equipped with an ST-4 compatible port.

In Solar System imaging, digital video cameras like the Altair GP-CAM are used to capture a series of videos that can be later processed with stacking software to reduce the blurring effects of our atmosphere. The resulting still image shows significantly more detail than any single video frame. We tested the camera on the Moon and Jupiter, and later fitted the supplied wide-angle lens and turned it on the winter sky to check its suitability for longer exposures.

Getting set up

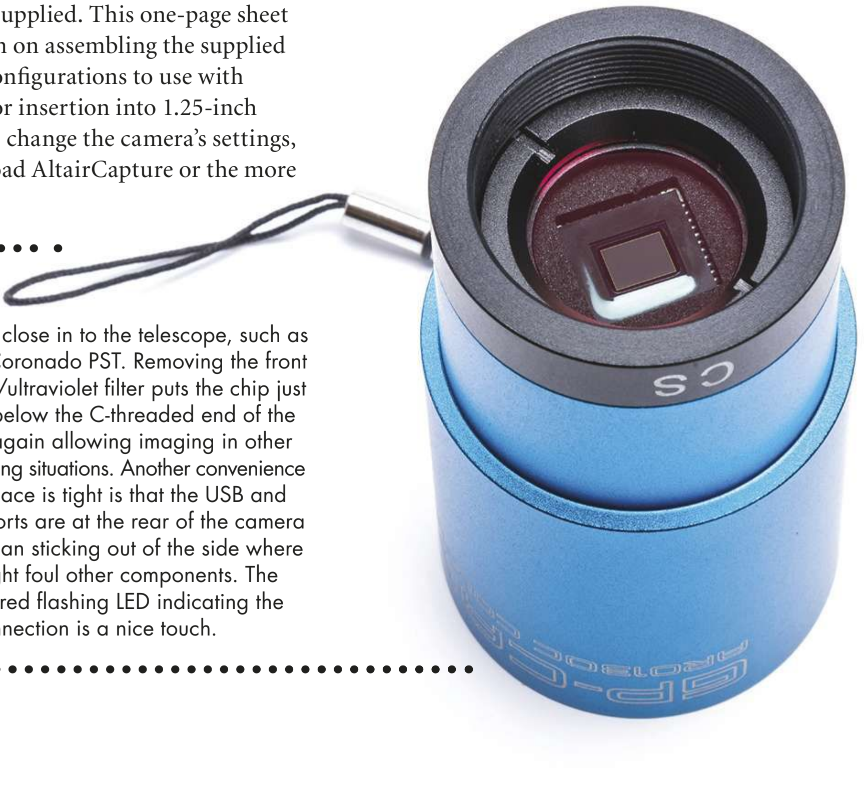
Before use, the correct drivers need to be installed. This was straightforward following the simple printed instructions supplied. This one-page sheet also gives information on assembling the supplied parts into different configurations to use with C/CS-mount lenses for insertion into 1.25-inch telescope focusers. To change the camera's settings, you'll need to download AltairCapture or the more sophisticated SharpCap software. It is a shame that the camera does not work with the popular FireCapture camera control program, which is more elegant and feature rich.

On our first outing we attached the camera to a 9-inch Newtonian telescope and used it to image the Moon with and without a 2.5x Powermate lens. With its 1280x960-pixel chip we were able to image larger regions of the Moon at high resolution, showing good detail and smooth greyscales. We converted the video to monochrome in the freeware program PIPP before aligning and stacking in Autostakkert! and sharpening in RegiStax. With the Moon being so bright, we could use short exposure times and low gain when recording. However, even at the maximum USB speed setting we could only run at full frame at 14 frames per second (fps), which is relatively slow for a modern USB 2.0 camera. Even at a reduced field size of 320x240 pixels we could only reach about 80fps, well short of the stated 200fps for this frame size.

We made the most of a brief period of calmer seeing to image Jupiter a few hours later, with ▸

WELL THOUGHT OUT DESIGN

The GP-CAM is a nicely crafted camera of CNC-machined anodised aluminium, compact and well thought out in form. Internally it is designed to carry heat from the chip to the body to reduce thermal noise in longer exposures. The cylindrical shape and stepped 1.25-inch barrel of the body, where the chip is positioned in front of the step means that the chip can actually sit 10mm inside the 1.25-inch barrel of a focuser or Barlow lens. This allows imaging where the focal plane is close in to the telescope, such as with a Coronado PST. Removing the front infrared/ultraviolet filter puts the chip just 7.5mm below the C-threaded end of the barrel, again allowing imaging in other demanding situations. Another convenience when space is tight is that the USB and guide ports are at the rear of the camera rather than sticking out of the side where they might foul other components. The unusual red flashing LED indicating the USB connection is a nice touch.



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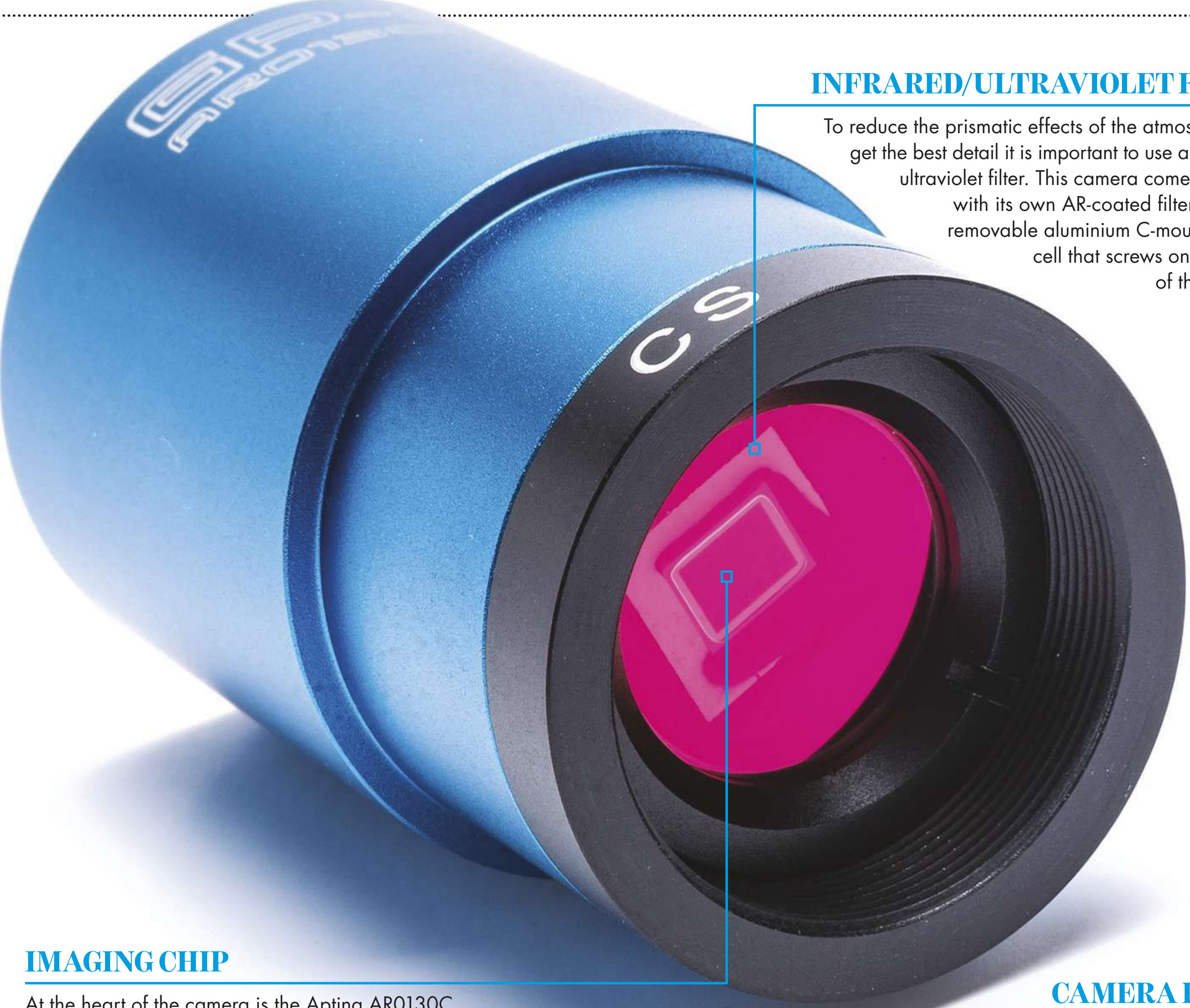


INFRARED/ULTRAVIOLET FILTER

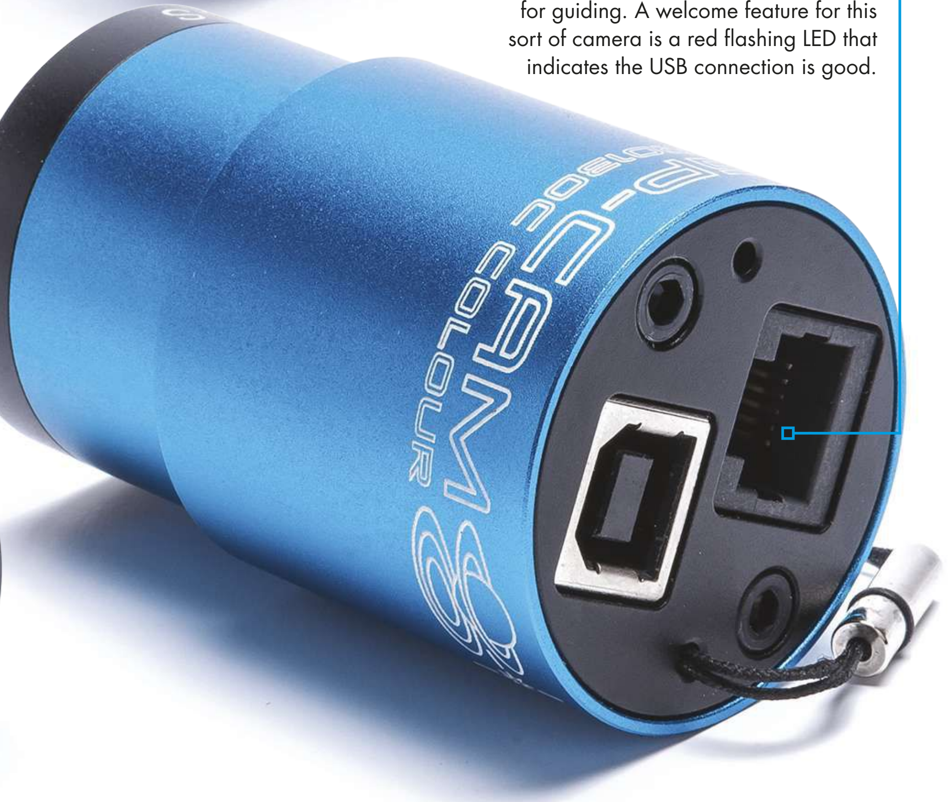
To reduce the prismatic effects of the atmosphere and get the best detail it is important to use an infrared/ultraviolet filter. This camera comes complete with its own AR-coated filter, held in a removable aluminium C-mount adaptor cell that screws onto the front of the housing.

IMAGING CHIP

At the heart of the camera is the Aptina AR0130C imaging chip with 1,280x960-pixel array. Each pixel is 3.75μm square making the chip 4.8x3.6mm. Like a lot of recent digital video cameras, the chip is CMOS based rather than CCD based.

CAMERA REAR

The rear of the camera has two ports, USB 2.0 and ST-4. The latter allows you to connect to a compatible Go-To mount for guiding. A welcome feature for this sort of camera is a red flashing LED that indicates the USB connection is good.



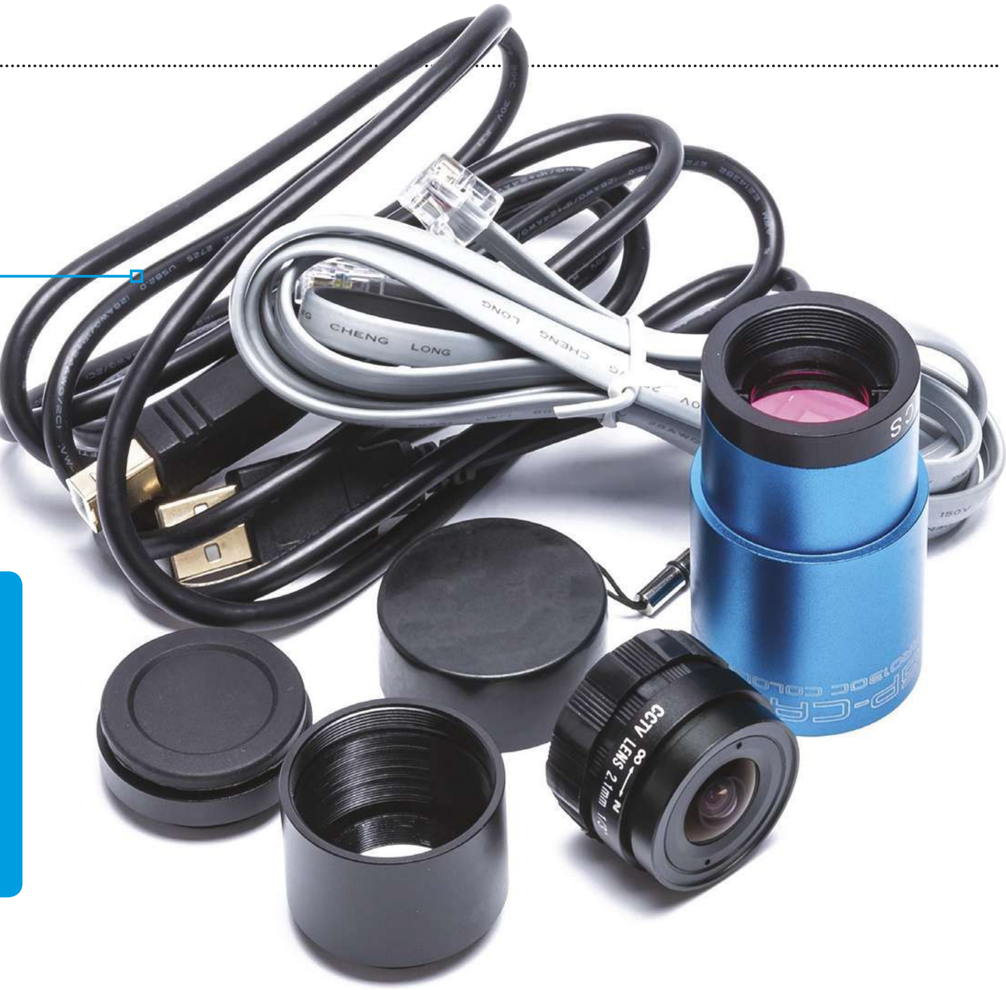
150° LENS

The supplied 2.1mm f/1.6 150° fisheye lens screws into the infrared/ultraviolet cell at the front of the camera. It allows you to create timelapse videos of the night sky, or to capture meteors or auroral displays.

FIRST light

ACCESSORIES

The camera comes with a good range of accessories. As well as generously long USB and guide port leads, there is a 150° lens, a 5mm CS to C-mount adaptor, a C-mount to 1.25-inch adaptor for insertion into an eyepiece holder and an infrared/ultraviolet filter.



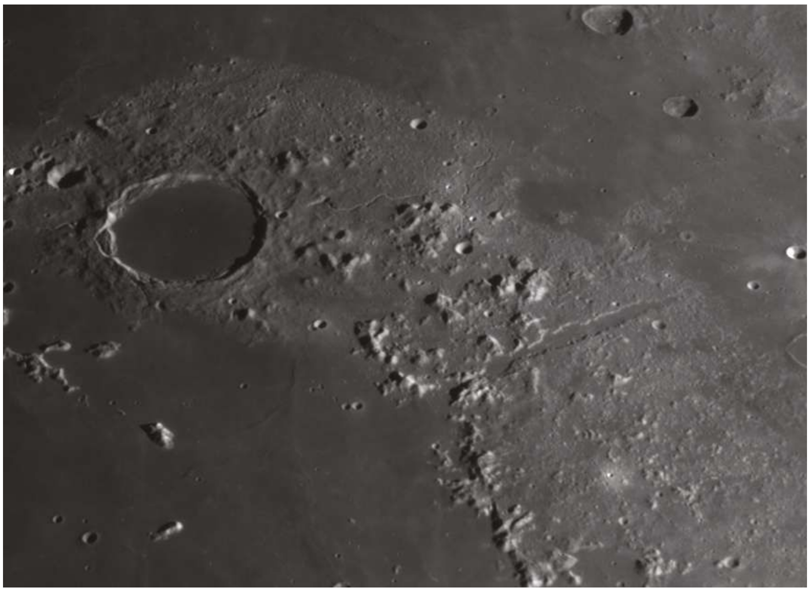
SKY SAYS...
Now add these:

1. GP-CAM universal tripod mounting clamp
2. GP-CAM USB cooler
3. Starwave 50mm guidescope and finder kit

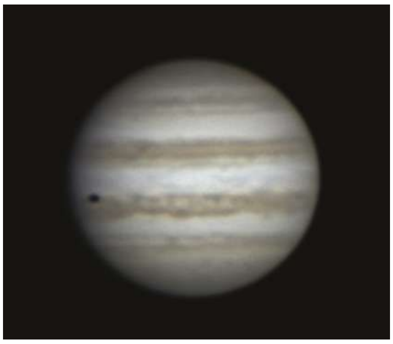
▸ the planet about 40° up in the south before dawn. Despite conditions being far from ideal, we were able to image some nice belt detail and the shadow of Io near the limb. We found the camera sensitivity to be high and noise levels to be low, running the camera at close to maximum gain with no visible artefacts or other issues.

As a test of the camera's performance for deep-sky imaging, we tried a much longer exposure than we had used for the Moon and Jupiter to capture the winter sky from a suburban location. To do this, we attached the camera to the supplied 2.1mm focal length, 150° fish eye lens. The camera is not cooled and so unsurprisingly we had lots of bright background pixels after a 15-second exposure, but after calibrating with a dark frame we were left with a pleasing result. We were also able to create a nice timelapse of Orion and the surrounding constellations, even showing the Pleiades as separate stars.

Overall the camera performed well and its compact size, high sensitivity and freedom from artefacts will make it a popular all-rounder for those starting out in digital video imaging, especially given the comprehensive set of accessories that come with it. Ⓢ



▲ Lunar crater Plato imaged with 2.5x Powermate and showing the fine sinuous rilles



▲ Jupiter and Io's shadow imaged with a 3x Barlow for 50 milliseconds

▲ A single frame from our 15-second shot of the winter sky after calibration

VERDICT

BUILD & DESIGN	★★★★★
CONNECTIVITY	★★★★★
EASE OF USE	★★★★☆
FEATURES	★★★★☆
IMAGING QUALITY	★★★★☆
OVERALL	★★★★☆

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TRIED & tested

We review well-established equipment that's stood the test of time

See an interactive 360° model of this scope at **www.skyatnightmagazine.com/revelation12**

VITAL STATS

- **Price** £575
- **Aperture** 303mm (12 inches)
- **Focal length** 1,212mm (f/4)
- **Optics** 1/12th-wave primary B270 glass; 94 per cent reflectivity dielectrically coated
- **Focuser** Crayford style with 1:10 fine focus adjustment
- **Extras** 8x50 finder, 35mm extension tube
- **Size** 356mm diameter, 1,200mm long
- **Weight** 20kg
- **Supplier** Telescope House
- **www.**telescopehouse.com
- **Tel** 01342 837098

SKY SAYS... This is a great instrument to buy as a base with a view to upgrading components

WWW.THESECRETSTUDIO.NET X 4, NEVILLE FOX

Revelation 12-inch f/4 M-LRN Newtonian reflector

A fast 'light bucket' that comes with an attractive price tag

WORDS: PETE LAWRENCE

Reflectors are often described as having the best aperture to price ratio of any type of telescope and the Revelation 12-inch f/4 M-LRN Newtonian reflector certainly adheres to that. Costing less than £600, this huge instrument is capable of delivering loads of light to your eye or camera sensor. Its large and fast primary mirror means that this telescope earns the title 'light bucket'.

The parabolic primary mirror's f/4 focal ratio gives a focal length of 1,212mm. The optics are held in place by a sturdy 356mm diameter steel tube. Including tube rings, this instrument is a hefty 20kg and probably on the handling limit for a single person. We mounted it on a Sky-Watcher AZ-EQ6 GT mount using a Losmandy dovetail plate. This is a perfectly workable arrangement as long as there's no wind. If there is, a couple of extra counterweights are in order.

Collimation proved straightforward although we couldn't help feel the adjustments were a little basic. The act of touching and releasing the collimation screws caused the marker of our laser collimator to move off target slightly. On the other hand, the supplied 8x50 non-illuminated finder – used throughout the Revelation range – was a decent size and easy to use. A Crayford style focuser incorporating a 1:10 geared-down fine focus facility is also provided, as is a 35mm extension. The main focuser accepts 2-inch fittings but also comes with a 1.25-inch adaptor.

Due to its size we needed to give the scope more than two hours to properly cool down before use. A 12V fan in the base of the tube can be used to speed up this process if required. Our first test subject was M42, the Orion Nebula. Although an easy target, its familiar appearance provides a great reference point.

Lost in the view

Our first low-power (38x) view of the nebula was superb. The Trapezium Cluster stood out against the subtle wisps of nebulosity. View contrast was pretty good throughout, and the dark lane running between M42 and neighbouring M43 very evident and detailed. Following the arms of the nebula was easy and we really felt you could lose yourself in the view. Nearby is the Running Man Nebula, NGC 1977. In front of it, dark dust lanes form the outline of a running stick figure. Although quite subtle, this 12-inch scope revealed it with ease.

Slewing up to the belt star Alnitak (Zeta Orionis) and slipping the star just out of the field of view revealed the large and surprisingly ominous Flame Nebula, NGC 2024. Distinctive dark dust lanes appear in front of the glowing nebula, breaking it up into a flame-like structure. Once again the view was superb. ▸

OWNER'S OBSERVATIONS

Name Neville Fox
Location Llanbrynmair, Powys
Equipment Revelation 12-inch f/4 M-LRN Newtonian reflector
Owner since March 2013

"I bought this scope as I was looking for a fast imaging Newtonian to use at my observatory. With a guidescope and cameras attached I need seven 5kg counterweights to balance the scope on its EQ6 mount and can track up to 20 minutes with off-axis guiding. I principally use a Fuji IS Pro DSLR for imaging, coupled with either a Baader MPCC III or an ASA Keller 0.7x coma corrector/reducer, which gives me a ridiculously fast (f/2.9) instrument.

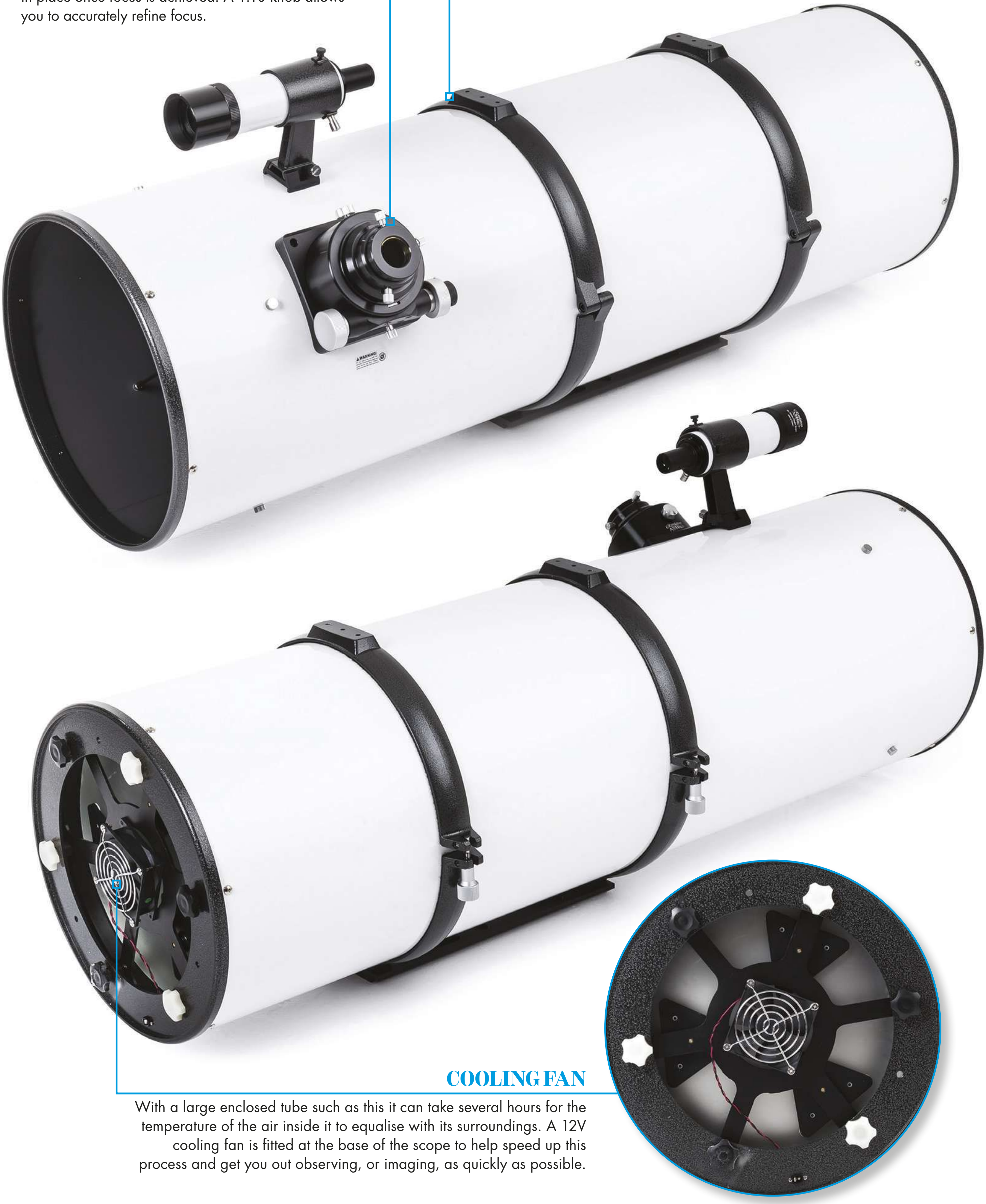
Precise collimation is necessary at f/4 (even more so at f/2.9) so I use a high-end laser collimator. Being a steel tube scope, collimation and focus may need checking between targets if the temperature changes much during a session. Modifications so far include uprating and increasing the number of mirror cell springs from three to six and adding a beefed up dovetail mounting bar (500mm long by 25mm thick) to give added tube support."

FOCUSER

A Crayford-style focuser is provided. This is a solid performer capable of handling up to a 5kg load. A tension screw is used to tune the focuser to your preference, while a locking screw holds it securely in place once focus is achieved. A 1:10 knob allows you to accurately refine focus.

STEEL TUBE AND RINGS

The optical components are held in place by a sturdy steel tube. A set of tube rings with a Vixen/Synta dovetail plate is provided. For this size of instrument, the wider Losmandy dovetail provides more stability. For added security, opt for a long dovetail plate rather than a short one.



COOLING FAN

With a large enclosed tube such as this it can take several hours for the temperature of the air inside it to equalise with its surroundings. A 12V cooling fan is fitted at the base of the scope to help speed up this process and get you out observing, or imaging, as quickly as possible.

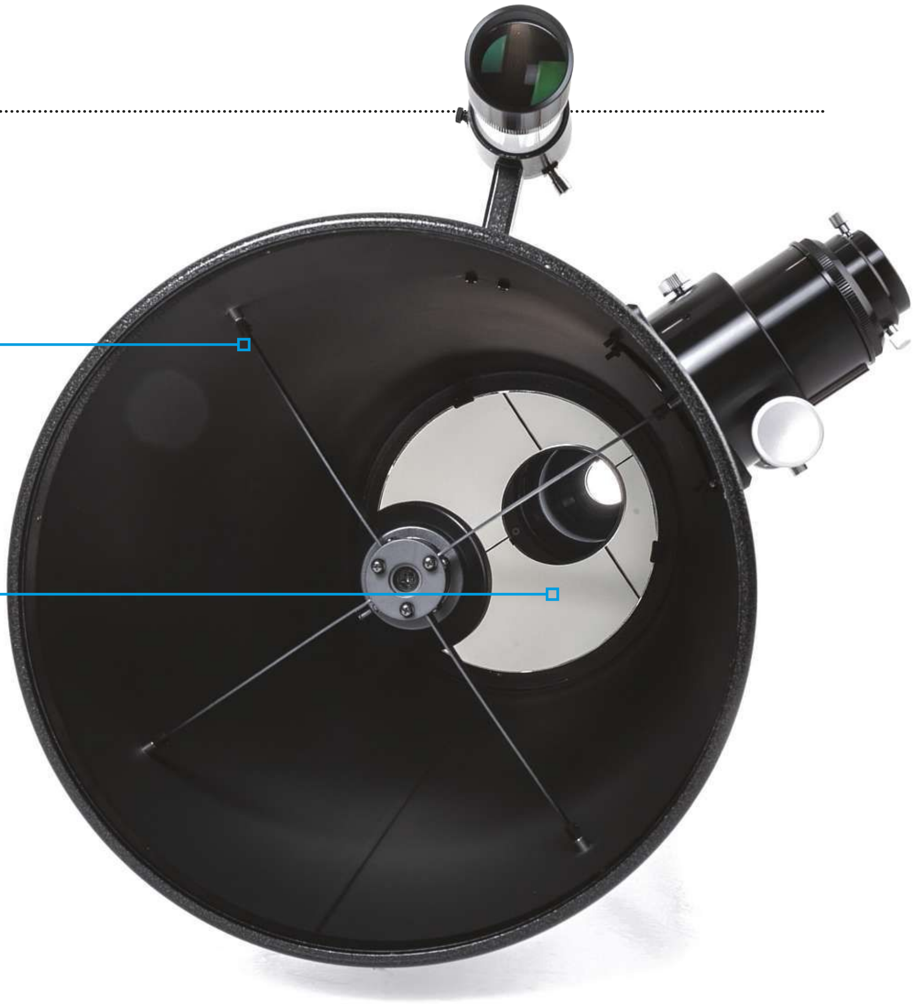
TRIED & tested

THIN SPIDER VANES

In the Newtonian design, the secondary mirror and its supporting 'spider' vanes block incoming light. For the round secondary assembly, this results in a small contrast drop. The straight spider vanes on the other hand produce diffraction spikes on bright stars. Here, the vanes are ultra-thin to minimise the effect of the spikes.

PRIMARY MIRROR

This scope possesses a high quality 1/12th-wave f/4 parabolic primary mirror. Its diameter is 303mm (12 inches), giving 2.3 times the light collecting area of an 8-inch scope or 1.5 times that of a 10-inch scope. At f/4 it is a fast instrument, perfect for unguided imaging setups or deep-sky visual observing.



SKY SAYS...
Now add these:
1. Sky-Watcher EQ8 Pro equatorial mount
2. Revelation 2-inch coma corrector
3. Explore Scientific 70° eyepiece kit

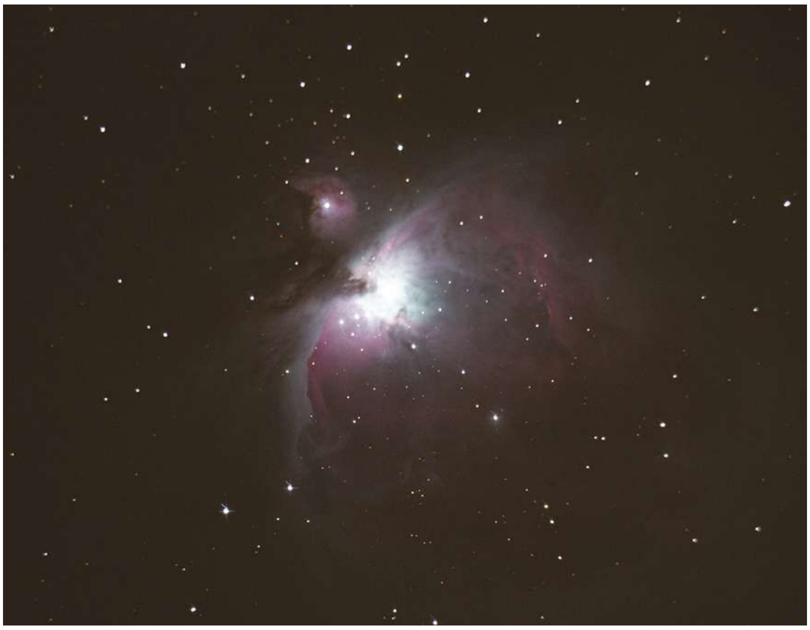
▸ When it comes to imaging this scope can deliver a large amount of light to a camera chip in a short amount of time, which is especially useful for unguided setups. In practice this worked really well, allowing us opportunity to capture faint subjects, such as the Horsehead Nebula, in seconds rather than minutes.

Being a reflector, coma is an issue and this was especially evident in captures taken with a full frame DSLR. The effect turns stars into what look like little comets, all pointing into the centre of the imaging frame and getting worse the further from the centre of frame you look. One solution is to crop off the worst regions, leaving just the sharper centre of frame. Alternatively, investing in a decent coma corrector should largely address the issue.

A big scope such as this is always going to be an exciting prospect. A great upgrade for a smaller instrument, the Revelation 12-inch f/4 reflector has the potential to deliver some serious results. At the price level, this is a great instrument to buy as a base telescope with a view to upgrading components as, and when, the need arises. Ⓢ

VERDICT

BUILD AND DESIGN	★★★★☆
EASE OF USE	★★★★☆
FEATURES	★★★★☆
IMAGING QUALITY	★★★★☆
OPTICS	★★★★☆
OVERALL	★★★★☆



▲ A 13-second exposure of the Orion Nebula at ISO 3200

▲ Open cluster M41 in Canis Major, imaged for 20 seconds at ISO 4000

▲ The Seven Sisters in Taurus, imaged for eight seconds at ISO 4000

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The Centre for Lifelong Learning at the University of York has just launched its postgraduate diploma in astronomy, delivered online via distance learning and led by Dr Alex Brown. Bringing together students from across the globe to explore the shared wonder of the night sky, the programme will give students a solid foundation of knowledge which will allow them to undertake their own research. We'll explore radio astronomy through the infra-red and into the visible before travelling to ever-increasing energies of radiation to x-rays and gamma-rays, before concluding with neutrino, cosmic ray and gravity wave astronomy – time will also be spent considering the lives and deaths of stars. This exciting two-year, part-time programme starts 2016, and is aimed at home astronomers and the academically inclined. Applications are being taken now.

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Books

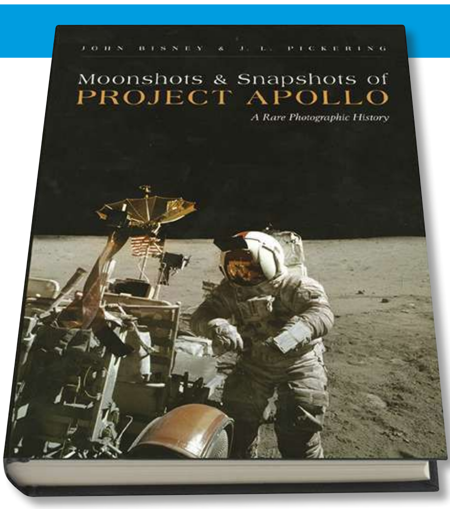
New astronomy and space titles reviewed

RATINGS

★★★★★ Outstanding
★★★★☆ Good
★★★☆☆ Average
★★☆☆☆ Poor
★☆☆☆☆ Avoid

Moonshots & Snapshots of Project Apollo

John Bisney & J L Pickering
University of New Mexico Press
£39.95 ● HB



For those of us interested in the Apollo story, this volume brings together an excellent variety of photographs from all of the manned missions. The 'snapshots' in the title refers to the author's decision to include informal snaps rather than rely on official NASA images. The result is a more human perspective that shows some of the individuals who worked on this gargantuan project.

Pleasingly, the book includes material from all the crewed missions that used Apollo hardware. The oft-overlooked rehearsal and test missions are covered, as well as Skylab's launch and three crews, and the final flight in 1975, when an Apollo craft linked up with a Soyuz capsule.

From the posthumously named Apollo 1, in which a fire killed all three astronauts during training, to the final link up, each chapter opens with a summary of the mission and then tells the story through pictures and detailed captions. There are plenty of rarely seen photographs, showing every aspect of each mission. The astronauts are shown learning their trade; for example taking geology field trips or training in the simulator. We also see the many different parts of the final vehicle being delivered, checked out and then moved to the massive Vehicle Assembly Building for stacking. There are some wonderful pictures of people working on the Saturn V after rollout to the launch pad, which really gives a sense of the scale of the Apollo vehicles. Also included are images of various safety posters, motivational badges and other ephemera from the programme.

The accompanying captions are well written and add up to a surprising amount of text to enjoy. A list of the many acronyms used by NASA is included along with photographic credits and bibliography.

The Apollo 15 crew relax; the book brings these informal moments to life

NASA

The only real negative aspect of the book is a lack of images from the flights themselves, as the photos focus more on preparation, launch and recovery. It would, however, be tough to choose which photos to leave out, and these are readily available online anyway. *Moon Shots and Snapshots* will certainly appeal to anyone interested in the Apollo era.

★★★★☆

MARK BOWYER *is an expert in the US manned space programme*

TWO MINUTES WITH JOHN BISNEY

What inspired you to write the book?
My co-author J L Pickering and I were teenagers during the Apollo missions and have been manned spaceflight enthusiasts ever since. It was our goal to provide a more comprehensive look at the people, equipment, processes and locations involved in this great adventure than has been available until now. We wanted to identify as many of the rank-and-file space workers as we could, since they are rarely given their due.

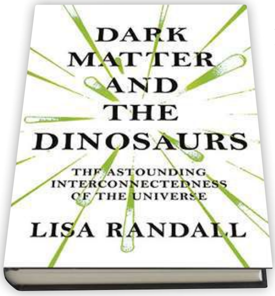
How did you find the photographs?
J L began to collect photos from the US space program as a teenager. We have both travelled to visit retirees around the country, since some of the best images came from NASA personnel and news photographers who were covering the space program in the 1960s and 70s. It is amazing what J L found in basements, attics and sheds. He also spent many hours digging deeply into the files at the Kennedy Space Center, Johnson Space Center and NASA Headquarters. He developed personal relationships with agency photo experts, who granted him unprecedented (and sometimes unofficial) access to the back rooms.

What new perspective do the photos bring to the Apollo missions?
We devote a full chapter of images to each flight and so were able to include astronaut training, the arrival and processing of the hardware involved, and what happened after the missions. This provides a much more complete look at the scope of this astonishing undertaking.

JOHN BISNEY *is an author and journalist who has covered the space program for more than 30 years*

Dark Matter and the Dinosaurs

Lisa Randall
Bodley Head
£25 ● HB


DARK MATTER AND THE DINOSAURS
THE ASTOUNDING INTERCONNECTEDNESS OF THE UNIVERSE
LISA RANDALL

Here's the recipe for an intriguing popular science book: take two parts cosmological mystery, two parts death of the dinosaurs and one part origin of mankind. Add a dash of personal flavour and mix thoroughly. Serve with imagination and enthusiasm. If theoretical physicist Lisa Randall is your chef, you're in for a wonderful treat.

In *Dark Matter and the Dinosaurs*, Randall delves into the origin of the Universe, the evolution of the Solar System, the extinction of the dinosaurs and the structure of the Milky Way. These topics seem to be pretty unrelated, but she succeeds in weaving them into a compelling story that ties our own existence to one of the biggest cosmological mysteries: the nature of dark matter.

Her thesis? A small part of the mysterious dark matter in the Universe might be self-interacting through an as-yet-unknown force. If so (and it's a big if), the central plane of our Galaxy is expected to harbour a thin dark matter disc with a substantial density. Every time our Solar System bobs in and out of this dark matter disc, comets are gravitationally dislodged from the distant Oort cloud and start to fall towards the Sun, causing periodic extinction events on Earth, including the one that killed off the dinosaurs and paved the way for the rapid evolution of mammals.

Lots of speculation here – even the assumed periodicity in the terrestrial impact record is still debated – but it all makes for a good read. As the author herself writes: "A fascinating Universe is out there for us to cultivate, cherish and understand."

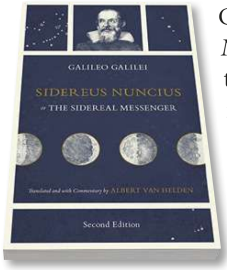
★★★★☆

GOVERT SCHILLING *is an astronomy writer and author*

Sidereus Nuncius

BOOK OF THE MONTH

Galileo Galilei
(Translated by Albert van Helden)
University of Chicago Press
£12 ● PB


GALILEO GALILEI
SIDEREUS NUNCIUS
or THE SIDEREAL MESSENGER
Translated and with Commentary by ALBERT VAN HELDEN
Second Edition

Galileo's *Sidereus Nuncius* was a statement that brought astronomy into the modern world. It could be argued that the book was the most dramatic scientific publication of all time.

Following the original transcription, published in 1989, Albert van Helden highlights the recent developments in scholarship relating to this important moment in the history of science. This edition includes an excellent introductory section, thorough and informative footnotes and improved and expanded bibliography and index, all of which allow us to view and place Galileo's work in its contemporary and scientific context and to fully appreciate the celestial wonders it announced.

Galileo was a firm subscriber to the Copernican hypothesis, and his observations of stars that had hitherto been invisible to the unaided eye, together with the discovery of the true nature of the Milky Way, offered radical and empirical proof of the nature and make up of the Universe. However, it was his observations of mountains and valleys on the Moon, and of four 'stars' or moons orbiting Jupiter, that served up what was perhaps the most convincing argument to accelerate our view of the Universe from a geocentric to a heliocentric nature.

Although *Sidereus Nuncius* has not actually changed since it was originally published, our ability to learn from it has improved dramatically. Galileo clearly knew and believed that it would be a far-reaching publication. Albert van Helden's well-presented transcription, based on the Venice 1610 edition's original Latin text published some four centuries later, certainly bears that out.

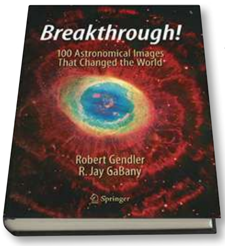
★★★★★

BRIAN JONES *has written 15 books on astronomy and space*

Breakthrough!

100 Astronomical Images That Changed the World

Robert Gendler and R Jay GaBany
Springer
£19.99 ● HB



Most people are attracted to astronomy either because they are lucky enough to have seen a truly dark, star-filled night sky first hand or (and more likely) through the magnificent pictures taken by satellites and telescopes such as Hubble.

Such images are now so commonplace that we may be in danger of taking them for granted, so this new book is welcome, succinctly telling the story of modern astronomy via a superb gallery. The authors, highly regarded amateur astrophotographers, provide detailed commentary on each image, ably weaving together technical and scientific information.

The story starts in the mid 19th-Century with daguerreotypes of the Solar System, and takes us to the present day with the development of digital cameras, including images taken by space missions such as Cassini. Hubble is the star of the show, providing breathtaking pictures of star-forming regions, supernovae and galaxies.

However, astronomy's dependence on images didn't start with photography, and I would like to have seen included Galileo's drawings of Jupiter's moons, which put the Copernican revolution on a firm footing in the 17th Century. More recently, Eddington's iconic photographs of the 1919 solar eclipse, providing the first observational evidence for general relativity, surely merited inclusion?

This isn't a hands-on book; don't read it expecting tips on how to create your own images. But it's a beautiful summary of the best that astronomy has to offer.

★★★★☆

PIPPA GOLDSCHMIDT *is a writer and astronomer*

Gear

Elizabeth Pearson rounds up the latest astronomical accessories

1

2

3

1 Altair Astro Solar Finder

Price £29.99 • **Supplier** Green Witch
www.green-witch.com

By bringing a projection of the Sun onto it backplate, this simple device allows you to quickly and safely align your telescope for solar observing.

2 Constellation Umbrella

Price £20 • **Supplier** Royal Observatory Greenwich • http://shop.rmg.co.uk

Even if the night is cloudy and raining you can still see the stars thanks to this umbrella, the inside of which is printed with the constellations of the northern hemisphere we all know and love.

3 Bresser Universal Smartphone Adaptor

Price £30 • **Supplier** Harrison Telescopes
020 8979 6809 • www.harrisontelescopes.co.uk

Make afocal photography easier with this adaptor, which lines up your smartphone with a telescope eyepiece to help give you steadier images. It's compatible with most smartphone.

4 Geoptik Nadira Observing Chair

Price £89.99 • **Supplier** Rother Valley Optics
01909 774521 • www.rothervalleyoptics.co.uk

This chair's adjustable height and angle means you can find the perfect position for a lengthy observing session.

5 NGC Miner

Price £4.99 • **Supplier** Pindussoft
https://itunes.apple.com

Get the most out of your deep-sky observing sessions with this iPad app of the NGC and IC catalogues. Search out the statistics of your favourite objects, then keep track of your observations in a digital log.

6 Heat Holders Thermal Socks

Price £6.99 • **Supplier** Heat Holders
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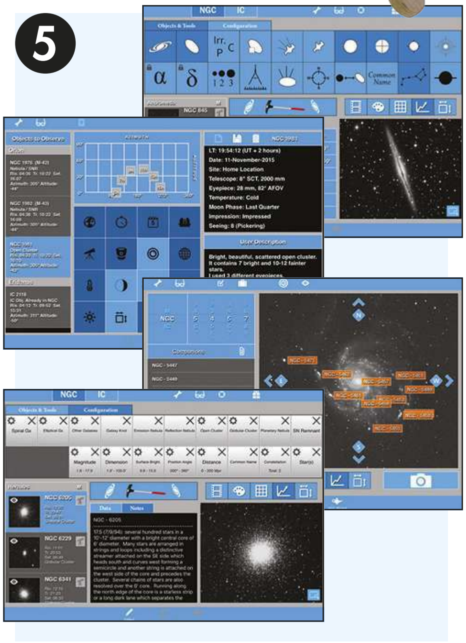
4

5



LT: 19:54:12 (UT + 2 hours)
Date: 11-November-2015
Site: Home Location
Telescope: 8" SCT, 2000 mm
Eyepiece: 28 mm, 82° AFOV
Temperature: Cold
Moon Phase: Last Quarter
Impression: Impressed
Seeing: 6 (Pickering)

User Description

Bright, beautiful, scattered open cluster. It contains 7 bright and 10-12 fainter stars.
I used 3 different eyepieces.

6

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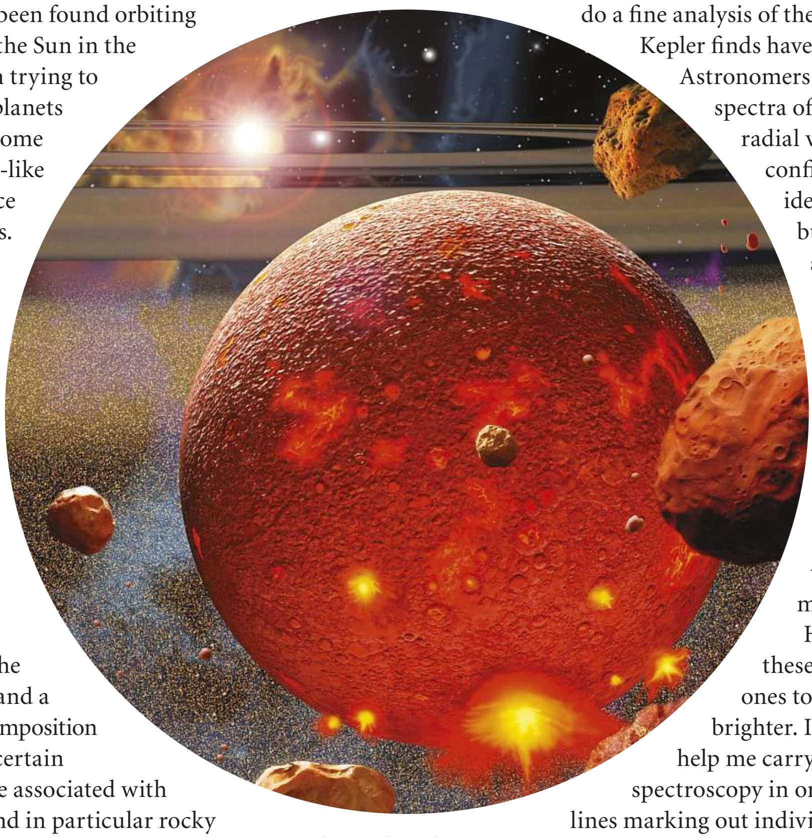
WHAT I REALLY WANT TO KNOW IS…

What kinds of stars form rocky planets?

Simon Schuler is checking the chemistry of other star systems to try and identify which ones might produce Earth-like worlds

INTERVIEWED BY PAUL SUTHERLAND



We know that planets coalesce out of gas and dust, but quite what causes them to be rocky, Jovian or anything else still eludes astronomers

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Thousands of planets and planetary candidates have been found orbiting stars other than the Sun in the past 20 years. I'm trying to discover which stars form planets and which don't, and why some stars only form large Jupiter-like planets while others produce smaller worlds more like ours.

Small rocky planets are particularly interesting because we think that's where life is most likely to arise. Understanding them better could help tell us how Earth formed. We know that stars and their planets formed from rotating discs of gas and dust, but the fine details of how that happened is still a mystery.

One way to learn about the connection between a star and a planet is by looking at the composition of the star itself. Are there certain patterns there that might be associated with the formation of planets, and in particular rocky planets? Using a space telescope such as Kepler is extremely expensive. My team is aiming to identify the signature in a star that indicates the presence of a rocky planet using a ground-based telescope and spectroscopy. If we can crack that, then a large-scale survey from the ground could be much less expensive.

Tell-tale star signs

I began my research in 2006, before any small rocky exoplanets had been discovered. At that time we just knew about so-called hot Jupiters, orbiting very close to their host stars. We discovered then that stars with those giant planets tended to be more metal-rich than stars that didn't – in other words they contained more of the elements that are heavier than hydrogen and helium, such as carbon, oxygen, nitrogen, sodium, magnesium and iron. The levels of all heavier elements within stars with giant planets seemed to be enhanced.

Now that Kepler has discovered several small planets, we've turned our focus to those. We're primarily using data collected by a spectrograph on the Keck Observatory in Hawaii. That allows us to do a fine analysis of the compositions of stars that Kepler finds have small planets.

Astronomers in the Kepler group take spectra of these stars to check for radial velocity variations that can confirm whether Kepler has identified a true planet or not, but I can use those same spectra to do my chemical composition work. So we're getting extra science out of their data.

We've not looked at many stars so far – my latest research paper covers just seven. I have a student who is working on another 10 stars, and then in the works we have maybe five or six more.

High-quality data is key, so these stars tend to be the closer ones to us because they are brighter. I need lots of photons to help me carry out high-resolution spectroscopy in order to see the spectral lines marking out individual elements. Some astronomers have automated techniques to measure stellar compositions, but for fine analysis like mine, we have to do it by hand, using specialised computer software. That limits the number of stars we can study in a short amount of time.

Our most interesting discovery, from the seven stars we've looked at with small rocky planets, is that their compositions don't appear to be any different from stars where we don't know if they have any rocky planets or not. So although we haven't detected any special signature, it seems there's no reason why every star can't form a rocky planet. You need an enhanced composition of elements to form Jupiter-type giants, but to form small planets you don't.

Some astronomers believe a pattern of elements will be found. While we do not see such a pattern in our stars, our sample so far is obviously small, so the next thing to do is examine more stars to provide statistically more significant data. Kepler's secondary mission, called K2, is identifying more bright stars with rocky planets, giving us a good source of fresh targets.

ABOUT SIMON SCHULER

Simon Schuler is an assistant professor of physics at The University of Tampa, Florida, where he is supported by NASA in the quest to learn more about planetary formation.

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The Southern Hemisphere in March

With Glenn Dawes

WHEN TO USE THIS CHART

1 MAR AT 00:00 UT
15 MAR AT 23:00 UT
31 MAR AT 22:00 UT

The chart accurately matches the sky on the dates and times shown. The sky is different at other times as stars crossing it set four minutes earlier each night. We've drawn the chart for latitude –35° south.

MARCH HIGHLIGHTS

Jupiter, being at opposition, is at its largest and brightest for the year. On two evenings this month the moons Io and Europa, and their shadows, can be seen crossing the planet's disc. This period begins on the 4th when Io commences its transit at 21:37 EST and ends at 22:39 EST with Europa's shadow egressing. On the 11th this grouping reconvenes when Io's shadow ingresses at 23:25 EST and ends when Europa completes its transit 90 minutes later. To convert times to WST, subtract two hours.

STARS AND CONSTELLATIONS

The southern constellation of Puppis is situated between the bright stars Canopus (Alpha (α) Carinae) and Sirius (Alpha (α) Canis Majoris). It was part of the traditional constellation of Argo Navis. It is home to numerous bright stars, including L2 Puppis, one of the brightest Mira-type pulsating variables. It ranges from approximately 6th to 3rd magnitude and can be followed with the naked eye throughout its 141-day cycle – a great target for beginners.

THE PLANETS

March sees Jupiter shining brilliantly in the northeastern sky near mag. +1.4 Regulus (Alpha (α) Leonis). Mid-month, Mars rises with mag. +1.1 Antares (Alpha (α) Scorpii) around 22:00 EST, followed by Saturn an hour later. In the mornings, Venus and Mercury are visible in the eastern dawn sky. March opens with Mercury 7° below its neighbour but is lost by mid-month to the solar glare. Venus continues to rule the dawn through the month.

DEEP-SKY OBJECTS

Puppis is home to many open star clusters. There's quite a grouping near mag. +3.3 Xi (ξ) Puppis. This star also makes a wide binocular double with mag. +5.3 HR 3043, 5 arcminutes to the southwest. From Xi Puppis look 1.5° northwest to mag. +6.2 open cluster M93 (RA 7hr 44.5m, dec. –23° 51'). It consists of approximately 60 mag. +8.0 to +10.0 stars arranged in a wedge around 10 arcminutes long.

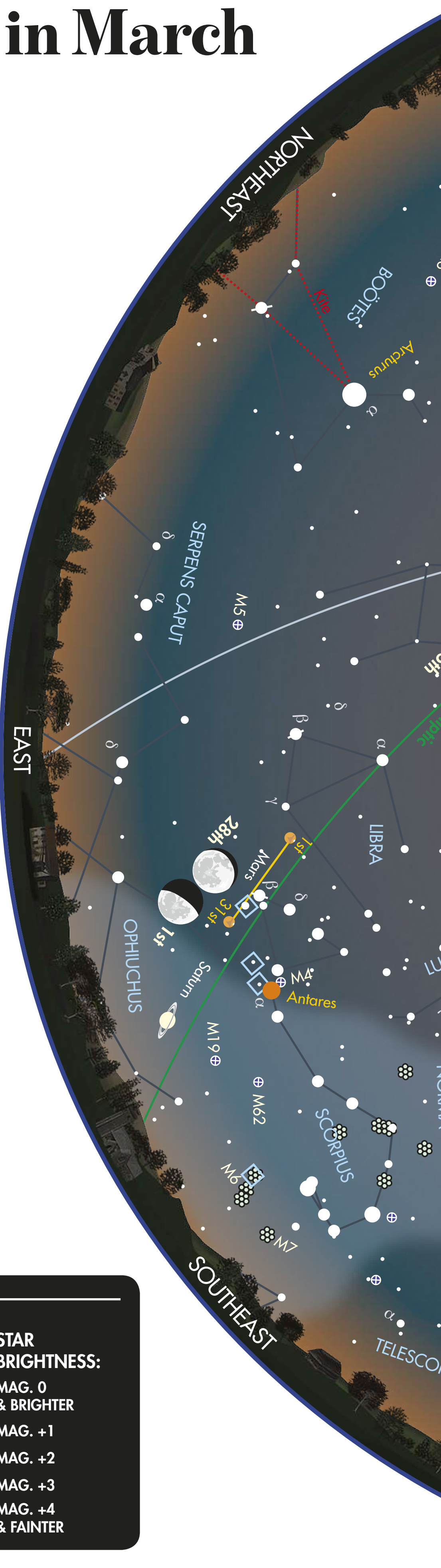
Returning to Xi Puppis, jump 1.7° south-southeast to reach NGC 2467 (RA 7hr 52.4m, dec. –26° 26'; pictured). This bright nebula in a rich starfield has an easily visible bright knot measuring three arcminutes with a prominent mag. +9.0 star embedded within. Look for scattered dark nebulae and the triangular open cluster Haffner 18 to the northeast – all this should fit within a low-power (50x) eyepiece.

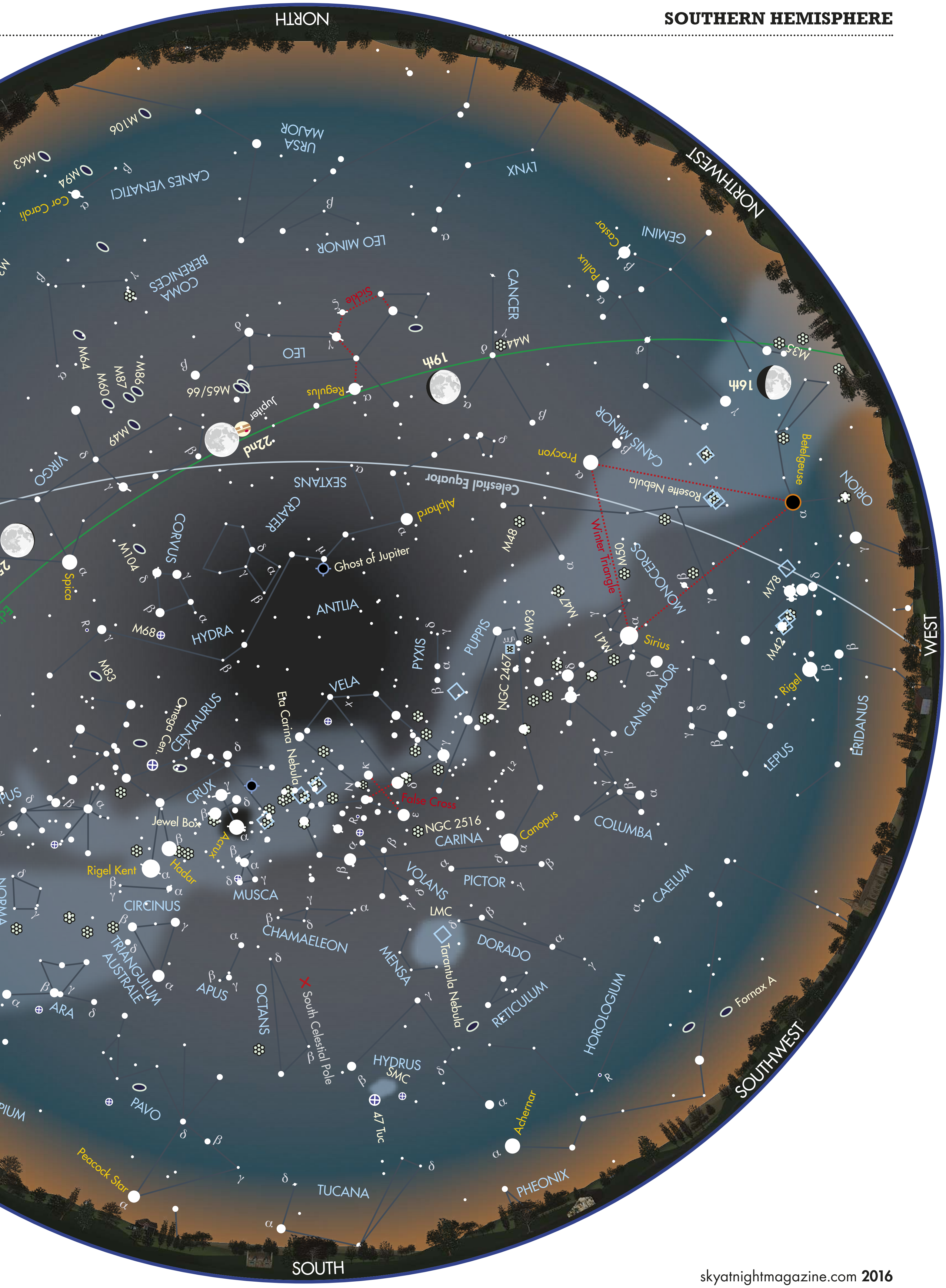
BERNHARD HUBL/CHRISTOPH KALTSEIS/WOLFGANG LEITNER/HERBERT WALTER/CCDGUIDE.COM

CHART KEY

⬭	GALAXY
◌ ❁	OPEN CLUSTER
⊕	GLOBULAR CLUSTER
☼	PLANETARY NEBULA
□	DIFFUSE NEBULOSITY
●	DOUBLE STAR
○	VARIABLE STAR
☄	COMET TRACK
⋰	ASTEROID TRACK
△	METEOR RADIANT
☼	QUASAR
🪐	PLANET

STAR BRIGHTNESS:
● MAG. 0 & BRIGHTER
● MAG. +1
● MAG. +2
● MAG. +3
· MAG. +4 & FAINTER

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NORTHWEST
WEST
SOUTHWEST
SOUTH
URSA MAJOR
LYNX
CANES VENATICI
Cor Caroli
M106
M63
M94
LEO MINOR
GEMINI
Castor
Pollux
COMA BERENICES
CANCER
Sickle
M44
M35
LEO
Regulus
19th
16th
M65/66
Jupiter
22nd
M86
M87
M60
M64
M49
VIRGO
CANIS MINOR
Procyon
Betelgeuse
ORION
Rosette Nebula
Celestial Equator
SEXTANS
Alphard
CRATER
CORVUS
M104
Spica
M48
Winter Triangle
M50
MONOCEROS
M78
M42
Rigel
Ghost of Jupiter
ANTLIA
HYDRA
M68
M83
PYXIS
PUPPIS
M93
M47
M41
Sirius
CANIS MAJOR
NGC 2467
LEPUS
ERIDANUS
VELA
Eta Carina Nebula
Omega Cen.
CENTAURUS
CRUX
Jewel Box
Acrux
Hadar
Rigel Kent
False Cross
NGC 2516
CARINA
Canopus
COLUMBA
MUSCA
CIRCINUS
VOLANS
PICTOR
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